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THE DAWN OF EGYPTIAN CIVILIZATION: A GLANCE AT THE FIRST DYNASTIES OF THE OLD EMPIRE.

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[*A Lecture delivered before the* FRANKLIN INSTITUTE, *March 3, 1887.*]

DR. PERSIFOR FRAZER, in presenting the LECTURER, said that it was necessary, perhaps, to offer some explanation for the presentation of a subject of philological research in an Institution dedicated to the Mechanic Arts. But, firstly, the sisterhood of all methods of using the intellect has been established to such a degree, that the student of one domain is sure to be assisted by the victories in every other. Secondly, Egypt was more distinguished for originality, ingenuity, progress in commerce, manufactures, art, invention, literature, and profundity of thought in philosophy and religion, than any country which ever existed. The FRANKLIN INSTITUTE fosters those subjects of the above list in which the United States is in the van at the present date. There was, therefore, no lack of appropriateness in the inscription which Egypt placed over the department which was consecrated to her use, in the great universal exposition marking the first Centennial anniversary of our country: "From the oldest to the youngest nation."

But there is another and a utilitarian reason for the interest in Egypt on the part of those who maintain the standard of the FRANKLIN INSTITUTE; and that is, that our institution is the great depôt of patents in this city; and from recent developments in the establishment of priority in valuable inventions, by the courts, it would seem that we never could be assured of such priority until the last Egyptian inscription and papyrus had been deciphered. On behalf of the Committee on Instruction, and in the name of the President and Board of Managers of the FRANKLIN INSTITUTE, I have the honor of presenting Dr. George Sélikovitsch.

Dr. Sélikovitsch said:

LADIES AND GENTLEMEN:—Since Champollion, the great French archæologist, succeeded in deciphering the old writing of Egyptian hieroglyphics, at the beginning of the present century, the world has fixed its eyes on the ancient soil of the Pharaohs, rightly called, "the cradle of civilization."

With anxious curiosity, the learned archæologists of this day commenced to investigate the glorious remains, the dumb Sphinxes and the solitary Mummies of Memphis and Thebes. All these venerable ruins, which have escaped time's dilapidation, began to reveal to us the most extraordinary mysteries of ancient Egypt: her past; her religion; her philosophy; her poetry; her monarchs; her priests; her manners; her grandeur; and her decline.

We have all heard of Napoleon's famous sentence, "Soldiers! forty centuries look down on you from the pyramids." If the French monarch had known Egyptian history, he would have said: "Seventy centuries." Seven thousand years have, indeed, passed since the fourth King of the first Dynasty, Ouanephs, erected the pyramid at the town of Ka-Xemi, or "Black Bull." Six thousand years ago, Egypt was already an ancient country, with perfected language, laws and architecture:[1] I do not say, with a religion, because the deity had not yet a distinct designation.

Let us pass by the first three dynasties, which are still some-

[1] Various opinions have been expressed about the Egyptian chronology. Many savants have vainly tried to reconcile Egyptian chronology with the Biblical account of creation. Prof. Lesley, in his remarkable book, *Man's Origin and Destiny*, is of the number of Egyptologists who are rightly against this arbitrary reconciliation.

what wrapped in darkness, and begin at the fourth Memphite Dynasty.[1] Here, Egyptian history on the various monuments really begins. And what monuments! The great pyramid of Gizeh, the "splendor of pyramids," as it was called, was built by King Xufu (Cheops), successor of Snefru.[2] Yet, under this monarch, the æsthetic feeling is still obscure: "large" and "big" are synonymous with "beautiful" and "fine." The pious King Menkaura, Xufu's successor, seems to have given an important impulse to belles-lettres and fine arts, because Egypt attained at this time a remarkable organization in everything: the written language was formed, the architecture perfected in execution, the religion of sun-worship established, and political matters diplomatically conducted.[3] Harpists, poets, singers, prophets, acrobats, dancers and scribes make their appearance. The drama of Osiris is born, and will later exercise a total transformation of the Egyptian religion. We do not know from which historical

[1] The name of Menes, the founder of Memphis (*Men-Nefer*), is placed at the head of the royal lists of dynasties at Saqqarah, Thebes, and in the papyrus of Turin; but we have not proofs from monuments. The existence of King Atahuti, son and successor of Menes, to whom is attributed the authorship of some works on anatomy, is less enigmatic. The existence of Ouanephs, successor of Atahuti II, as the builder of the Ka-chemi pyramid, is historically proven.

[2] "No one can possibly examine the interior of the great pyramid," says Mr. Ferguson, "without being struck with astonishment at the wonderful mechanical skill displayed in its construction. The immense blocks of granite brought from Syêné, a distance of 500 miles, polished like glass, and so fitted that the joints can scarcely be detected. Nothing can be more wonderful than the extraordinary amount of knowledge displayed in the construction of the discharging chambers over the roof of the principal apartment in the alignment of the sloping galleries, in the provision of ventilating shafts, and in all the wonderful contrivances of the structure. . . . Nothing more perfect mechanically has ever been erected since that time."—*History of Archit., Vol. i. pp. 91, 92.*

[3] The Egyptian name of the pyramids was Ben-Ben and also Berber (with the interchange of the letters *n* and *r*). Ben-Ben signifies "splendid," from the root *ben* (*Denkmäler*, ii, 43 d) "delight, enthusiasm." Then, must we perhaps see in the Greek πυραμις *per-am*, "house of light." Besides these generic names, the pyramids have been designated by a multitude of rhetorical images, like *sep*, "head, summit," etc. The great pyramid Khufu's was called *Xu-t*, "the horizon," that of Chefrem was called *Uer*, "great," and the third small pyramid of Menkaura, *Har*, "the superior."

event the Osiris myth sprang (though, whenever we see a legend, we may be sure that it is based on some historical allusion); we know only that Osiris was aknowledged as a deity in the reign of Menkaura of the IVth Dynasty. We find in this monarch's coffin the following prayer: "*Oh, Osiris! King of Upper and Lower Egypt, Menkaura! Ever-living, born of Nut, Essence of Seb. Thy Mother Nut is protecting Thee: She granteth Thee Divinity and destroyeth Thy Enemies, Oh King Menkaura! Living forever!*"

A complete religious transformation begins with the apparition of this God: nay! a complete philosophical transformation. Has not the legend always been the parent of æsthetic meditation? Would the sublime poem of Job exist, and Goethe's masterpiece, "Faust," if they had not legends for their origin? The old Egyptian legend is the terrible struggle between Osiris the God of life, or *Un-nefer*,[1] the "Excellent-being," and his brother Typhon or Set, the God of gloom and darkness.

The sombre drama of Un-nefer took place, according to the later tradition, at the fabulous period when the Gods Ptah, Ra and Seb reigned over Egypt. Seb was succeeded by Osiris and his wife Isis. Then came Set, the brother and rival of Osiris, and the terrible duel began between them. Set was victorious and killed his brother. Lastly came Har, or Horus, the orphan avenger of his father and the conquerer of Set. According to the Egyptian mythology, these deities reigned 13,900 years.

Since Set committed this crime,[2] peace and happiness disappeared from the world, to give place to physical and moral evil. The most ancient hieroglyphic texts give us a full account of this dramatic event, and the scribe neglected nothing to acquaint us with the agonized lamentations of Isis and Nephtys "the two divine sisters." A papyrus found in the ruins of Thebes[3] in the interior of a statue representing Osiris, contains an Egyptian jeremiad, and I take pleasure in giving you some fragments of it:

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[1] In Egyptian *un* "to be; being," and *nefer* "good, beautiful."

[2] According to Plutarch (on Isis and Osiris, chap. 13) the tragic death of Osiris occurred on the seventeenth day of the Egyptian month *Athyr*; see my article in the *Melitz* of St. Petersburg, 1886, No. 71.

[3] Now at the Royal Museum of Berlin, numbered 1425. We give here only selected fragments of this long and touching elegy; see Dr. Brugsch's "*Adonisklage und das Linoslied*," 1852. The copy of it belongs to the new Empire.

"SUPPLICATION BY ISIS.

She says:

"Come to thy abode, return to thy dwelling!
—Thine enemies are no more,
Oh beautiful prince! Come, come to thy abode.
Look at me: I am thy sister who loveth thee. Do not stay far from me, Oh Superb Youth!
—Alas! I see no more thy face. My heart is filled with woe on account of thee.
Mine eyes seek thee vainly.
—Shall it be long before I see thee? (bis.)
Beholding thee is happiness. (bis.)
—Come to thy Sister, come to thy wife. (bis.)
—Do not separate from me.
Gods and men look upon thee with tears.
They all sigh for thee when they behold me.
I call thee in elegies to the heights of heaven, and thou hearest not my voice.
I am thy Sister who loveth thee on earth;
No one else hath loved thee more than I,
Thy Sister! Thy Sister!"

This fight between rival brothers was inevitable from the beginning of creation: the world having for maker a Good God, it is natural that the God of Evil should declare himself an enemy of the whole creation. Jehovah found himself, many centuries later, in the same situation when confronted by Satan. The mischievous intentions of the Biblical Satan are directed against mankind only, while the Egyptian Satan, Set,[1] desires a complete annihilation of the whole creation; he prefers chaos to the universe, and darkness to light.

This mystic and everlasting war does but symbolize the strange situation forced on humanity during its short transit on earth, or, rather, it symbolizes the question of physical and moral evil imposed on man. The theologians of the land of the Pharaohs have gone farther with their symbolic sentiments: they have compared God to the "nursing Nile," and the bad spirit to the desert which invades Egypt with its ardent billows. Thus, God's war

[1] Set was selected, during the rule of the Hyksas (shepherd kings), as the sole national deity, to the exclusion of any other Egyptian gods. King Seti, of the 19th Dynasty, paid an unusual homage in adopting his name. Set became finally unpopular. His worship ceased at once, and his name was suppressed from the monuments.

against the bad Spirit becomes a duel between the Nile and the Desert[1].

This philosophical conception of religion, if I may so express myself, has its basis on the legend of Osiris, who appears for the first time at the IVth Memphite Dynasty, about 4,000 years before Christ. At this time the chapters or the rolls of *The Book of the Dead* were yet unknown. The Deity had not yet a distinct name, but was simply represented by the dog-headed Anpu or Anubis, whence sprang, later, the Greek mythological dog Cerberus. Anpu was considered as the Watch-dog of the tomb, as were the Cherubim (Watch-bulls) at the door of paradise, and like the Assyrian Kerebu (bulls) which were the symbolical guardians of the royal palaces of Nineveh[2]. At the most ancient tombs of Memphis, those of Amten and Tee, the invocations are addressed to Anubis alone, while the great procession of myths is yet in its cradle. It becomes powerful in the XIth Dynasty, when the tender Isis appears as a Goddess, and with her comes the birth of the Beautiful, in letters and Art.[3] The famous maxim of a French magistrate, "Cherchez la femme," may be applied to the domestic arrangements of the Gods: the Woman or the Goddess has influenced lofty sentiments wherever she has appeared. (What a pity that the jealous Jehovah was not kind enough to introduce this element into his heavenly court! What a charm would have been added to the books of Isaiah, Job, Psalms, Solomon's love-song, etc., if we had had the intervention of a gracious Goddess in these great symphonies of human thought![4])

Pardon this little digression; and now let us go back to the Vth Dynasty. We find the original worship of the Sun developed and connected with that of many other deities.

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[1] G. Maspero, *Histoire Ancienne des Peuples de l' Orient.*

[2] See my pamphlet, "*Le Schéol des Hébreux*," p. 12.

[3] The Museum of Boulaq possesses of this dynasty, stelas, vases, clothes, furniture, arms, etc.

[4] The Hebrew language has no name for "goddess." The modern Hebrew writers generally use for goddess *bath ha-shamaïm*, "celestial daughter." The proper Hebrew expression would be, *benath ha-Elohim*, "the daughters of Elohim," thus contrasting with the *sons* of Elohim, mentioned in Genesis vi., 2, and Job ii, 1.

The Supreme Gods Amon "the Invisible," and Xeper "the Self-produced," become identified with the Sun by new theologians. Philosophical humanity is then born with the Prince-philosopher Ptah-hotep, who lived at this time. Antiquity has transmitted to us the moral precepts that Ptah-hotep wrote when he was 110 years old (*Papyrus Prisse*).

Permit me to quote some of his sentences, written about thirty-three centuries before Chirst—

"Be encouraged by knowledge. Reason with the ignorant as well as with learned men."

"The son who accepts the advice of his father will grow old, because obedience emanates from God and disobedience is condemned by God."

"The heart is the Sovereign of man, as regards obedience and disobedience, but still man is free to form his heart by obedience."

"Wash away the impurity of thy mouth, and conform thyself to the precepts of the Lord."

"Happy is the man who honors his father, from whom he sprung."

"Blessed is he who fulfils his father's commands, for a good son is cherished by God."

The old prince finishes with an autobiographical notice:

"I am now one of the oldest men in my country; having passed my 110th year of life, thanks to my august sovereign, and his court, whom I have faithfully served; and hence I merited his goodness."

One might suppose these sentences were detached from a chapter of Wisdom, preached by King Solomon, who lived about seventeen centuries later.

Not only did philosophy flourish, at this time, but all the other branches of cultivated thought. Even the Turquoise mines of King Snefru, of the IVth Dynasty, were skilfully worked by his successors, the Kings Sahura, Raenuser and Menkaura, as appears by the late discoveries at Wadi-Magarah. As for architecture and the fine arts, we have from this early period (the IVth and Vth Dynasties), the pyramids of Gizeh, that of Abousir, the statue of Chefren,[1] founder of the second pyramid, besides the

[1] Shafra (others read *Xafra*) or Chephrem means "born of the sun *Sha - f - ra*," like the names of the King Ramessu, of the 19th Dynasty. Other born of the sun Egyptologists translate generally "Ra is his sunrise" (*Xa*), without considering the important point that "sunrise" does not occur *at all* in the names of the Old Empire, and even the names Ra-Sha-Xeper and Ra-Sha-Khau signify probably, "Ra, producer of the universe," and "Ra, producer of beings."

splendid tombs at Saqqarah and at the pyramids. We have also, from this period, a magnificent temple, built of alabaster and granite, discovered by Mariette-Bey at the feet of the Great Sphinx; an inscription of Xufu,[1] founder of the first pyramid; a handsome wooden statue, representing a private citizen; a fine sarcophagus of granite (of the IVth Dynasty); and fifty monolith-stela, statues, etc., which are now to be seen in the Museum of Boulaq.[2]

Egyptian fine arts undergo a slight decadence at the time of the VIth Dynasty: neither temples nor other monuments were built: but on the other hand, the Hydra of war makes its first appearance.[3] We possess a tolerably long inscription, from this period, by a General called "*Una*." He entered the court of King Teta, first as a Prophet-priest, and later became Royal scribe or Secretary of State under King Merienra (Pepa), and finally rose to the rank of General, as he tells us himself.[4] He carried on a campaign against the "*Amu*" tribes (perhaps the *Emim* of the Bible), some of the Asiatic neighbors of the Egyptians, and against the *Herusha* people. He concentrated an army of the *Nahsi* (negroes) from the Ethiopian lands, and made with them several incursions against the *Herusha*. Remark here the very important fact that negroes make their appearance in history for the first time.

Una attacked the enemy, burned their forts, destroyed the vines and fig trees, killed a good many of their people, and finally forced them to submit. But this submission not being complete, Una was again compelled to concentrate another army and to defeat them again. He was highly rewarded for his military services, and this reward from his King was that he was not obliged to take off

[1] Many explanations have been given of the name of Khufu; I think that it is either the old root *Xef*, "name, title;" or *Khep*, "to erect," then "the erecter." The eldest son of Noah was equally named Shem, "name."

[2] Mariette's *Rèsumè of Monumental Authorities*.

[3] It is true that we have already mentioned conquests at the IVth Dynasty, on a tablet found at the mouth of the ancient *Makfa* mine: King Snefru is represented there conquering some tribes of the East; but *war* is not mentioned before the VIth Dynasty.

[4] Inscription found by Mariette and placed in the Museum of Boulaq. A partial translation was given, first by de Rougé, in his *Rechèrches sur les Monuments: Les Six Premières Dynasties*, Paris, p. 117. The entire translation of Una's inscription is given by S. Birch (*Record of the Past*), Vol. ii, pp. 3–8.

his sandals when he entered the royal palace. Una adds with proud satisfaction (line 35), "Never before was such an honor accorded to any other official."

Let us do justice to the gallant Egyptian officer, in stating that his record contains but little of the element called *chauvinism*, or *jingoism*. He speaks rather as an impartial historian than as an officer. What a difference between his record and the annals of King Thotmes III, of the 18th Dynasty, who exhausted in his vocabulary every sanguinary and blood-thirsty expression to qualify his victories![1] The reason for this may be because Una began his career as a priest, and did not receive an early education in barracks, which often robs a man of the gentler experiences of life.

At this early period, Poetry had not been prostituted to sing the savage scenes of human butchery. War was not yet glorified, as it was a few centuries later. Like our truly civilized selves, the subjects of Pharaoh, had the same fanaticism—that most awful scourge of humanity—the belief that their own country was superior to the whole earth, and that citizenship overshadowed fellowship. All that was not from Ta-meri, "the beloved country," was irrevocably condemned. After all, why should not the nation of Xam have had her "Out of Egypt there is no salvation," as well as other nations, which, urged by that strange but universal sentiment of selfishness, have proclaimed that they were *the* "elect?" Did not wise Greece adopt this same prejudice? Did not ancient Rome term those "barbarians" who had not been favored by fate in having been born on the blessed soil of Jupiter? And that nomadic people of Canaan, the future nation of Israel; did they not contract an irrevocable alliance with God, to the exclusion of all the other nations of the globe, because these latter invoked their Creator under various names of Baal, Kamosh, Dagon, Ashtaroth, Ptah, Ra and Osiris, instead of designating him by the autocratic name of Jehovah? Thus we have had everlasting wars, fought on account of trifling synonyms. We must not be surprised, then, if the river Nile has, in ancient times,

[1] Tablet of Thotmes, found at Thebes, in the Karnac quarter. This extraordinary tablet was published first in the *Archæologia*, Vol. xxxiii, p. 373, and afterwards translated by the Vicomte de Rougé, *Revue Archéologique*, 1861, p. 196.

resounded with war songs as wicked as those heard to-day in civilized Europe. The famous song of Thotmes III, the records of Rameses II (the Sesostris of the Greek writers) their strange chauvinism, as marked on the New York obelisk[1] and elsewhere, may serve as a prototype of the future "*Marseillaise;*" "*Wacht am Rhein*" and other poetic (!) inspirations of this kind, with their horrible mission, "to glorify crime."

No, no! Poetry has nothing to do with the miserable jingle of sanguinary and homicidal strophes; poesy does not inspire them, as she never inspired criminal hymns, the ancient Phœnicians sang, with pious enthusiasm, to their horrible Moloch, while they immolated to him rosy babes. It is unfortunately true that the modern Moloch—Mars—has, like his antique Phœnician prototype, his temple, his priests, his adorers, and, especially, his innumerable victims. But he has no poets; the Muses and the Furies never can be sisters.

But if the Egyptians had, like ourselves, laws whereby crime was permitted, encouraged, sung and glorified, legitimate indignation never has ceased to protest energetically against them by the mouth of wise men like King Amen-em-hat. We have already quoted some philosophical sentences from Ptah-hotep; let us now see what is King Amen-em-hat's opinion about war. This monarch (he would be termed to-day, by newspapers, a "bombastic monopolist"), who reigned in the XIIth Dynasty, left a testament to his son, Usertasen I, wherein he explained how he had once been obliged to fight "because he was miserably assaulted."[2] He says (line 3):

"Rely on thyself, Oh, my heart, because man has no friends in the day of misfortune. However, as for myself, I have assisted the helpless and strengthened the powerless. I have granted assistance to him who wanted it and to him who already had it."

Line 5th is very touching; he says, with pride, that he has prevented war, and deplores bitterly the fact that man, as oblivious as a bull, likes always to recommence fighting, in spite of the terrible consequences which he has already experienced.

"*My image will be durable among men because I have suppressed*

[1] The New York obelisk belongs to the period of Renaissance.

[2] Papyr. Sallier ii, pl. I, 1.—I, pl. III, 19. It is dated by the Scribe Enna-Enna: the first year, second month of Pert, day 20th.

the cries of the afflicted. No more battle-fields! Wonderful to say that fighting ever took place before (I suppressed it), *Oh bull forgetful of yesterday!*"[1]

To this old Empire is to be attributed the formation of temples and colleges in Thebes and Memphis as well as the celebrated university at "*On*" (Heliopolis), where was built Egypt's first *temple* and theological college. "*On*" is now a miserable village called Metarieh, five miles from Cairo). The art of embalming was taught as well as anatomy. Dissertations on theological subjects, and on religious philosophy (everything being connected with religion), were debated; such as, "*Invisibility*" (Amon)[2] and "*Self-production*" of the Supreme being (Xeper), as well as regards the immortality of the soul. The soul was supposed to emanate from the Sun and appeared after death before Osiris, the judge of the dead, who was assisted by the forty-two assessors in the hall of Truth and Justice. But besides this ultra-terrestrial justice, the Egyptians were provided with laws punishing crime and offences. Murder, theft, adultery and demonolatry were punished by decapitation.

We must not be too much surprised at the severity of judgment regarding adultery. The gentler sex of the Nile Valley were not models of female virtue, if the Egyptian women were really as they

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[1] M. Maspero (*Records of the Past*, vol. II, p. 12) translates this difficult passage: "And yet it had been fought before (as if the land were) a bull forgetful of yesterday," which is not clear, even with its hypothetical restitution. The translation I propose without restitution, is also justified by the papyrus text, and gives a satisfactory sense: "O bull forgetful," referred to man, cf. Isaiah 1, 3, where we find the same rhetorical image.

[2] Originally, *Amon* was not identified with *Ra*, and the union of the two divinities took place about the 18th Dynasty; thenceforth *Amon* was worshipped as *Amon-Ra*. Bunsen, *Egypt's Place in Universal History*, vol. i, p. 371; *Records of the Past*, vol. ii, pp. 20, 31, 34, etc.; Rawlinson, *Hist. of Eg.*, vol. i, p. 325. *Ra* was adored at On, called by the Greeks *Heliopolis*, "the city of the sun," and at Thebes he was identified with *Amon* and adored as *Amon-Ra*; at Memphis he was united with *Ptah* and *Pasht*.

Amen means in Egyptian "to conceal, to hide;" hence comes the mysterious place called *Amenthys* or *Amenti*, which corresponds to the Greek Ἀιδης and the Latin *Orcus*. Plutarch explains in his *de Isis et Osiris*, Chap. 29, that Ἀμένθης means ὁ λαμβάνων καὶ διδους. This explanation is probably based on the Coptic words *Amoni* (to take), and *Ti* (to give). Plutarch has ignored the fact that the real etymology of *amenthys* is Ἀμοῦν τὸ κεκρυμμένον.

are depicted in some hieroglyphic romances and in historical texts. The female education was concentrated on music, and on the fine arts only; science and letters were ever considered useless for women, whose only mission on earth consisted in the art of pleasing and in nothing else. But we must not conclude, therefore, that the Egyptian women were considered as instruments of pleasure alone, as they are in the barbarous conception of Islam. The Egyptian lady was never secluded in a harem, but she enjoyed equal rights with her husband before the law. The dress of both sexes was nearly the same; gold collars, chains, bracelets, anklets and rings were worn by each; the ladies appropriating ear-rings to their own sole use.[1]

Leather and papyrus sandals began to be used in the Vth Dynasty; linen garments had been worn long before.

Pharaoh himself, was not considered, as many historians have thought, an autocrat, a kind of Czar, because he was nearly always assisted by Ministers, Royal scribes or Secretaries of State, Counsellors, and others, who formed a kind of *House of Lords*. In the army, we find Generals (hautu), Captains (menh-u), and lieutenants (ten-u). The Monarch was head of the army.

The Egyptians were fond of smybols and mystical allegories which always had a profound signification whether in a philosophical point of view, or from a high poetical standpoint. Thus the obelisk represents the mysterious and divine power of reproduction.[2] Even to this day, the same symbolical idea has been adopted by nearly all the nations of the world; we have only to glance at a church steeple to be convinced that the tower reproduces the shaft of the obelisk and the steeple the pyramidion.

The obelisk is also, to-day, the most common form of sepultural monument, symbolizing re-production,—re-creation.

As for the Sphinx, I think it a very high artistic conception. Imagine what high power and what inspired sentiments the artist must have had, who discovered how to combine together physical and intellectual force![3] The body of a lion and the head of a man. The strength and majestic aspect of the

[1] Cf. Birch's *Ancient History*, Vol. i, p. 15.

[2] The Egyptian word for obelisk is *teken*.

[3] Clemens, of Alexandria, says the Sphinx symbolized *αλκὴ μετὰ συνέσεως* "power with insight." The Egyptian names for Sphinx are *Xu* and *S-seps*.

graceful animal combined with intelligence, love and purity. Have you ever seen in any museum the smiling melancholy of a Sphinx? He seems to say in his ancient language:

"*Sa ret, her-a peter*
"*Au-a en neferu Xeper!*"
"Son of man look on me!
"I am the form of beauty."[1]

To this old Empire can be attributed the magnificent Hymn to Amon-Ra. There is no doubt, but that the handwriting of this hymn belongs to the 18th Dynasty, a short time before Joseph, the young Hebrew, came into Egypt; but the manuscript[2] says at the end of it, that "it is a copy of one of the oldest books that had been *discovered*;" and the Egyptians regarded it at this early time, as we regard to-day the poems of Homer—as a song of the ancients. By its archaic phraseology, too, we can refer it to the old Empire.

I will read you four strophes of this remarkable poem, which I have translated for this occasion—

Verse 3. Amon-Ra, superior of all the gods!
Thy goodness brings the gods to ecstasy
And they pay adoration to thee in the sanctuary.
Oh, thou who art crowned in the house of flame!
The gods love thy brilliant apparition
When thou comest from Arabia,
When thou sailest, O, prince of dew,
Through foreign lands to appear gloriously
In the divine region of Palestine.

[1] The Great Sphinx is called *Har-ma-Xu* on the granite tablet of Thotmes IV, of the 18th Dynasty, where the legend says "it grants power and pure life to the King."

The Great Sphinx, says G. Rawlinson, must be admitted to be a striking monument, and to impress the spectator, not only by its bulk, but by its air of impassive dignity. (*History of Eg.*, vol. i, p. 269.) But a charming description of it has been given by Ampère (quoted by Rawlinson, *loc. cit.*); "Cette grand figure mutilée est d'un effet prodigieux; c'est comme une apparition eternelle. Le fantôme de pierre paraît attentif; on dirait qu'il entend et qu'il regarde. Sa grande oreille semble recueillir les bruits du passé . . . Sur cette figure, moitié statue, moitié montagne, on decouvre une majesté singulière, une grande sérénité, et même une certaine douceur."

[2] A fac-simile of this hieratic papyrus (numbered 17 in the Boulaq collection) has been published by Mariette: *Les Papyrus Égyptiens du Musée de Boulaq*. fo. Paris, 1872. pl. II, 13. The manuscript is perfect from beginning to end, and has been commented by M. Goodwin, Grébant and myself.

4. The gods rush to his feet
To acknowledge his Majesty as master,
As lord of terror and grandeur.
(They say to him): "O Lord of spirits![1] powerful!
Bringer of gifts, maker of presents!
Salutation to thee, Creator of the gods!
Thou hast suspended the heavens,[2]
Thou hast laid down the foundations of the earth.[3]

8. Thou consolest[4] those oppressed by the tyrant.
Thou renderest justice to the poor and the martyr.
O! thou art Lord of righteousness because thy precepts are right.
The Nile overflows by thy will,[5]
(*Because thou art*) Lord of tenderness and love.
Thy rising brings life to men,
Thy apparition opens their eyes.
Thou actest also in the immensity of the sea.[6]
Distributor of delight and light!
The gods glorify his goodness.

13. Homage to thee, say all the creatures;[7]
Adoration to thee from all the regions;
From the height of heaven to the space of earth,
To the deep of the incommensurable sea.[8]
(Even there) the gods adore thy majesty.
The spirits thou hast produced praise
With joyful hymns their Maker.

---

[1] *Ur ba-u*, "chief of spirits." Moses applies the same epithet (*el elohe ha-ruchoth*) tanju in one of his prayers to Jehovah, which has no hebraic physiognomy. Moses, the adopted son of Rameses II, must have known this beautiful Egyptian hymn. Numbers, Chap. xvii, 22.

[2] *ax pet* corresponds literally to *nata shamaïm* of the celebrated psalm civ, 2.

[3] The Egyptian word for "earth" here is not *ta*, but *satu*, "the deformed earth," a very archaic form. The same image is employed (*bèiasdi ares*) by Jehovah, apostrophizing Job (xxxviii, 3).

[4] *Naâm*, or *naham*, "to alleviate," or "to console," and not "to deliver," as usually translated. *Naham* is a Shemitic word.

[5] See Ps. civ, 7–11.

[6] *Nu* designates, the abyss, as the Hebrew word *thehom*, and sometimes also, "the great ocean."

[7] Literally, "said by all the creatures" (*t'at en aut neb-u*).

[8] *Matui nat ur mer.*

They exclaim: come in peace[1]
Father of the fathers of all the gods,
Who supportest the heavens,
Who layest down the foundation of the earth![2]

The study of the antique Egyptian language is now well cultivated; it has already dictionaries, grammars, poetic treatises, periodicals and societies.[3] Egyptian is taught to-day in many of the universities of Europe by Egyptologists of renown. The United States is represented by many of them. I will mention here two only, because they are both living in Philadelphia, Admiral McCauley and Prof. J. P. Lesley. The first is the author of a *Dictionary of Egyptian Hieroglyphics*, published in the *Transactions of the Philosophical Society*, and has still some other valuable manuscripts on the favorite subject he cultivated when between sky and sea.

Prof. J. P. Lesley, amidst his geological and philosophical studies, has endowed Egyptian archæology with valuable dissertations by commenting learnedly on hieroglyphic texts. I desire to acknowledge my indebtedness to these Egyptologists of your city, who have kindly facilitated my task by the loan of scientific books and by their artistic taste. Nor should I finish without expressing my thanks to Dr. Frazer, of Philadelphia, who was good enough to introduce me so kindly before this select audience. The Doctor, who introduced me was right, when he said: "The FRANKLIN INSTITUTE is a great depôt of patents, and not until the last obelisk is deciphered, will we be certain of priority in telephones and steam

[1] *Aiui em hotep*, "come in peace," or welcome; an expression corresponding with the Hebrew *boi beshalom* (come in peace), and to the Arabic *ahlan washahlan!*

[2] I have translated some fragments of this beautiful hymn into Hebrew verses, with a short commentary, in the *Melits* of St. Petersburg, 1887, No. 37.

[3] See Champollion, *Grammaire Egyptienne*, Paris, 1836; *Dictionnaire Egyptien*, Paris, 1841; Lepsius, *Lettre à M. Rosellini sur le système hièroglyphique*, Rome, 1837; Birch, *Egyptian Grammar and Dictionary* in Bunsen's *Egypt*, vol. v; Brugsh, *Scriptura Ægyptiorum Demotica*, Berlin, 1856; *Hieroglyphisch-demotisches Wörterbuch*, Leipsic, 1868; De Rougé, *Grammaire Egyptienne*, Paris, 1867; Maspero, *Sur les pronoms et les conjugaisons, en egyptien et en copte*; Rawlinson, *Language and Writing*, vol. i, chap. iv, of his *History of Ancient Egypt*, London, 1881, Admiral McCauley, *Dictionary of Egyptian Hieroglyphics*, Philadelphia, *Trans. Am. Ph. Soc.* 1883, etc.)

engines." Nay, the centuries which built such gigantic artificial mounds, the pyramids of Gizeh; the people who, in the immemorial period of the first dynasties, cultivated anatomy and invented the art of embalming; the thinkers who have borne so high the the standard of artistic sentiment; such a people is capable of everything! Thanks to the French archæologist, Champollion, the first interpreter of the Egyptian Past; we have only to question the venerable ruins of the old Misraïm to make acquaintance with generations which have disappeared seventy centuries ago! We will never be certain of priority of thought in philosophy and æsthetics, until we reveal the remainder of the grand pages of civilization's first appearance;—until we find the first historical lines traced by a dawning humanity!

APPENDIX.

The want of Egyptian types in this city prevents the author from giving here an alphabetical explanation of all the words he employed in his Egyptian dialogue. But apart from this, an explanatory lexicon would be of no use for those readers who are not acquainted with the hieroglyphic writing, and superfluous for Egyptologists, who have but to take any Egyptian dictionary to find every word used in the dialogue, in its right place: the author having avoided, as far as possible, forced or arbitrary significance, notwithstanding the modern physiognomy of the subject.

This specimen of Egyptian literature being the *first* attempt to write in ancient Egyptian, the author leaves it to the judgment of philologists.

I have written the following Dialogue in the old Egyptian language with a translation, in order to show you that Egyptological studies are very progressive, since we are able to render in Egyptian even modern thoughts. The words I have used here are gathered from all periods.

ELECTRIC WELDING.

By ELIHU THOMSON.

[*A Paper read at the Stated Meeting of the* FRANKLIN INSTITUTE, *held Wednesday, March 16, 1887.*]

Ten years ago I had the pleasure of giving a course of five lectures on electricity in the hall of the FRANKLIN INSTITUTE, as part of the winter courses, and the leading idea I presented to my hearers was, that electricity from whatever source, and however manifested, is always of the same nature, and differs from that produced in other ways in its tension or potential, which is analogous to pressure in fluids, and in volume or amount of current, which is analogous to rate of flow of fluid or to the quantity moving in a pipe or conduit past a given position in a definite time.

Among the experimental demonstrations used to support this view, were some which were made with an ordinary induction coil, such as is commonly employed to obtain from low potential battery currents, high potential discharges through air, resembling lightning, or what is often called static electricity, such as is employed in the charging of leyden jars, etc.

After showing the induction coil as so used, I reversed the process and passed high potential discharges from a charged battery of leyden jars, through the fine wire coils of the induction coil, and received currents of low potential but of great volume from the coarse wire of the coil. By putting a low resistance galvanometer in the circuit of the coarse wire, known ordinarily as the primary, a strong deflection of the index of the galvanometer took place, and upon bringing the ends of the coarse wire coil together in slight contact, a bright green flash took place at every leyden jar discharge through the fine wire. While repeating this instructive experiment, showing the indentity of electricity and the reversibility of the induction coil, I noticed at one time that after the discharge the ends of the wire of the primary or coarse coil had stuck rather firmly together, and it then occurred to me that possibly metal wires might be united by properly organizing the appliances. My attention was turned, however, to the field of electric lighting, in the development of which field I have, since 1879, been almost

exclusively engaged. Some four or five years ago the need of a quick and effective method of joining together the ends of copper and other wires, as in the construction of our dynamo machines and other electric apparatus, presented itself. The joints, as ordinarily made, were formed by tapering each end and soldering or brazing them together sidewise, and the joints were of clumsy and uncertain character, unless made with great care; and, moreover, destroyed the flexibility of the wire at the joint.

It was at that time difficult for us to get wire of any considerable length in one piece, and as some of our dynamo coils contained about 300 pounds of copper wire, the making of several joints in the coil was unavoidable. My old experiments for the INSTITUTE lectures recurred to me, and I designed an apparatus for welding the ends of the wires together. This apparatus was constructed on the first opportunity, and far greater success was obtained with it than had at first been anticipated. What the results are will presently appear.

Larger and better apparatus was then constructed, and larger work accomplished, and I now see no reason why it would not be possible to construct machines for electric welding, which would work upon pieces a square foot or more in section, and am inclined to think that such work can be economically done.

It will be convenient to consider, (1) the source of electric current; (2) the means for applying the current to the pieces for welding; and (3) the welding operation itself.

It is believed that any electric current generator capable of giving volume of current depending on the sizes and nature of the metal pieces to be welded and of a low potential, or, at least, of low potential between the connections on each side of the joint to be made, will be suitable. As examples of such sources may be mentioned batteries of very low resistance, such as storage cells of large size, or a number of smaller cells coupled together in multiple, so as to combine their currents; dynamo electric machines giving either alternating or continuous currents, of large volume. Special designs of such machines are being constructed for the work. Another source of current and a convenient one, is a properly organized induction coil, or, as now often termed, a transformer or converter, taking alternating currents of comparatively high potential and small volume from a line connected with an

alternating current dynamo, and giving out currents of low potential and great volume, at the place where the work is to be done and where the induction coil exists. The principle of action and, in fact, the essential elements of the induction coil so used, in so far as the production of currents of low potential and of great volume, from currents of high potential and small volume is concerned, may be found in the reversed action of the induction or Ruhmkorff coil, shown in 1877, and before referred to. In the apparatus there are found two coils or conductors, placed parallel and near together upon an iron wire, or sheet-iron core, or in a laminated or divided iron sheath.

The coil or conductor which receives the high potential or high electro-motive force current is of comparatively small sized wire and of many turns, while that which furnishes the heavy welding current is of much larger section, or is composed of a strand or bundle of wires of few turns and of very low resistance, so that the large currents may freely circulate.

Whatever source of current be used, it is desirable to have the apparatus so controlled that the energy of the current may be adapted to the size and nature of the work to be done. Thus if a battery be used, a switch for putting on or taking off the current should be placed in its circuit and, where the power of the battery is to be applied to varying sizes of work, a variable resistance may also be put into its circuit, or the plates or cells of the battery may be used in sets, the number of plates or cells in a set being varied by a sliding switch. This arrangement is indicated in *Fig. 1*, where S, S^2 and S^3 are cells, one terminal of each being joined to clamp C, and the others left free, but capable of being connected with the clamp C^1, by a movement of the switch S, so that one or more cells in multiple may be in operation. The pieces in place for welding are represented by B and B^1. It would sometimes be convenient to have means of immersing the plates of the battery in the liquid to varying extents under control of the operator. These are all well known ways of controlling the available energy of either ordinary chemical batteries or of storage batteries.

Concerning the means for applying the current to the pieces to be welded, it may be premised that they are subject to considerable variations depending chiefly upon the forms and materials of the pieces. Generally clamps of heavy copper are provided so

that the pieces may be securely gripped and then abutted at the place where the weld is to be made. The clamping surfaces are best when shaped to the configuration of the pieces, or nearly

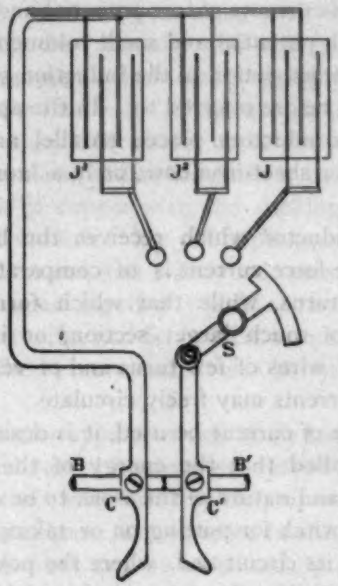


FIG. 1.

thereto, though the ease with which even flat clamping jaws may be used on curved or irregular work is remarkable. The clamps are, of course, kept insulated from each other except that they are connected with the terminals of the source of currents. While usually

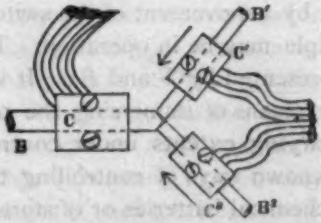


FIG. 2.

but two clamps are needed, the simultaneous joining of three or more pieces, as in making a fork by a common weld of three ends of pieces, is best done with a like number of clamps, *C*, *C*¹, *C*², *Fig. 2*, one

holding each piece with the current divided and distributed between the clamps. In the case of two clamps only being used, which is the common condition, either one or both clamps are movable towards and from the other. For most work this movement is in a right line secured by suitable guides, but for welding circular rings or curved pieces, the movement given is better made on a curve corresponding with that of the pieces. These are mechanical details upon which it is needless to dwell.

The force of a spring or of a screw, or even a manual pressure, is used to press the clamps and the pieces held by them together during welding. The amount of pressure used depends on the size and properties of the metal of the pieces. Tool steel requires more pressure than iron, because the weld must be made at comparatively low temperature, to avoid injury to the material. It may be here remarked that the clamps which hold the pieces and pass the current from piece to piece are sometimes fixed in position, when lap welds are to be made and lateral pressure or hammering is applied to force into union the lapping surfaces after the passage of current has heated them to the welding heat or temperature at which they are plastic enough to unite.

However, butt welds can be made electrically of so perfect a character that as applied to joining the ends of bars or plates, lap welding, while more slow and difficult, possesses no advantage in strength.

When the pieces to be united are too short to permit the application of clamps to them, they are simply inserted between blocks which press them together and convey current to them.

A form of apparatus suitable to the welding of wires and small bars is here shown, and it may be described as follows: It is an induction coil, whose iron-wire core, *II*, *Fig. 3*, has been wound over with a coil of primary wire *P*, to be traversed by currents from an alternating current dynamo. The outside coil or the secondary coil *S*, which generates the welding currents by induction from the primary wire, is co nposed of sixty-four wires in a strand, which makes only a few turns around the core. The ends of the secondary are bolted down to plates *P P'*, upon which the clamps *C C'*, for holding the pieces to be welded are mounted. One of these clamps *C'* is arranged to slide upon its copper bedplate, and is guided so as to move in a line towards the other clamp block, by the elastic force of a spring *Z*. During formation of a

butt weld, the movable clamp is drawn a little towards the other at the moment that the metal of the pieces is hot enough to yield at the abutting point. A cam *K*, is placed so as to be turned to hold

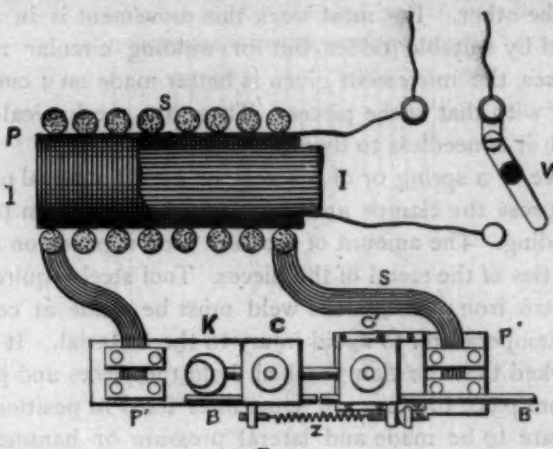


FIG. 3.

the clamps apart during insertion of the pieces in them. The complete apparatus is shown in *Fig. 4*.

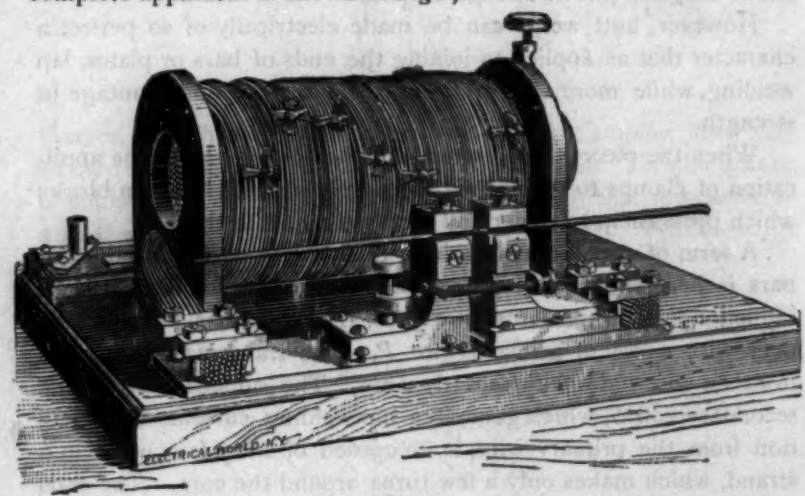


FIG. 4.

The operation of placing the pieces in the clamps is the work of a few seconds only. In this apparatus just described, the part consisting of the primary coil and iron-wire core is movable in and

out of the hollow secondary strand, to vary the power of the induced currents. On account of the short length of conductor in the secondary, *S*, the currents produced in it are of very low electro-motive force and of great volume.

In larger apparatus, such as has been employed for some of the heavier pieces here shown, the construction is different, but

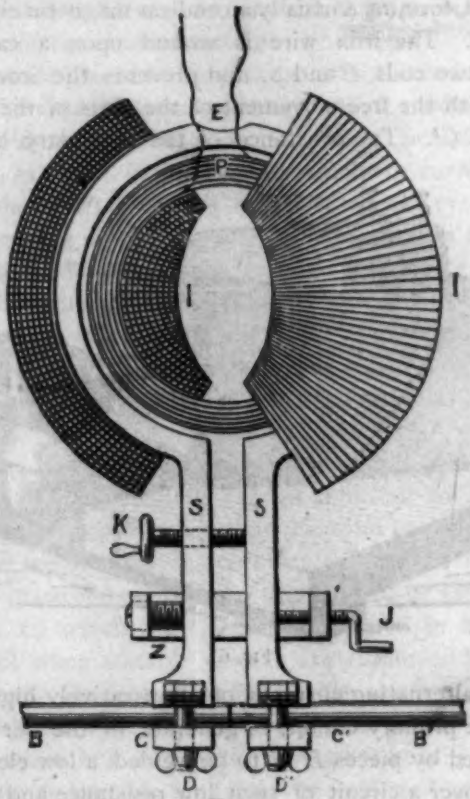


FIG. 5.

depends on the same principles. The primary *P*, *Fig. 5*, is a large, open ring, and is composed of many turns of insulated copper wire. The secondary, *S S*, is simply a single heavy bar of copper bent to make only one turn outside the primary coil, its ends are turned outward, and provided with powerful screw clamps, *C C'*, for holding the pieces, *B B'*, in place and in abutment. The form of the secondary is somewhat like a jews-harp, with the clamps on the

ends of the parallel portion. The bar, *S*, is thinned at *E*, and broadened there so as to give a certain flexibility. A powerful screw and spring at *Z F*, forces the clamps together when the apparatus is used. *Fig. 6* is a view of the larger apparatus complete.

Over both primary and secondary a heavy sheathing of iron wire is wound, forming virtually an endless magnetic circuit of iron around them. The iron wire is wound upon a casing which encloses the two coils, *P* and *S*, and prevents the iron wire from interfering with the free movement of the parts of the bar, *S*, and the clamps, *C C'*. The resistance of the secondary bar is about ·00003 ohm.

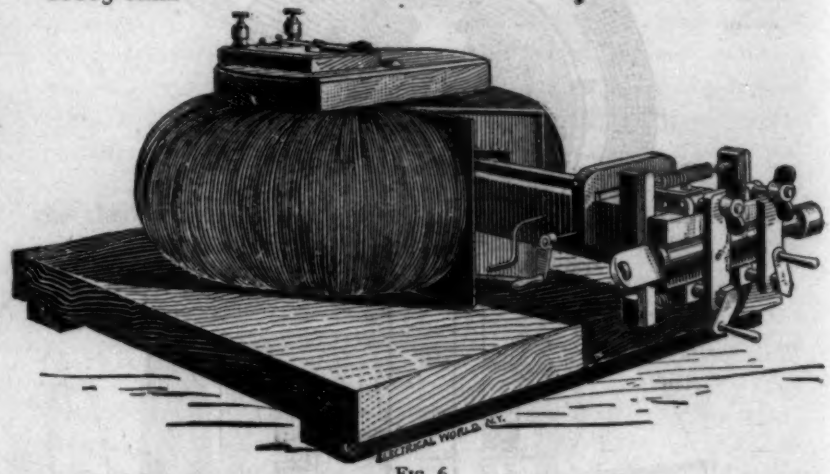


Fig. 6.

Vigorous alternating currents, of comparatively high potential, passing in the primary circuit, *P*, generate in the bar *S*, when its circuit is closed by pieces *B B''* to be welded, a low electro-motive force acting over a circuit of such low resistance and giving rise therein to currents of enormous volume, such as have hitherto been unknown in the electric art. Currents estimated to exceed 25,000 ampères have been present when doing some of the heavier work thus far attempted, and apparatus will soon be completed, which will far exceed this output, and proportionately larger pieces will be welded.

To prepare the pieces for the operation of welding by electric means, all that is necessary to be done is to clean those parts of

the pieces which enter the clamps by filing or emery, and to see that the ends or surfaces to be welded are clean enough to effect a contact when pressed together after placing in the clamps. The shape of the abutted ends matters little, as a joint will be formed even when the ends are irregular, but it is best to have the surfaces either flat, or with the edge chamfered a little, or with one or both surfaces made somewhat convex, in order that the joint may begin in the middle of the abutted section.

The pieces are placed in the clamps, with the ends to be joined projecting therefrom a small amount, and a moderate pressure tending to hold them in abutment, is applied. Sometimes at this stage, a flux, as borax, is added, after which the current is put on. Heating of the abutted ends at once begins and proceeds with a rapidity depending on the current flow, and the size and nature of the pieces treated, reaching the welding heat or temperature of union for the metal, or even reaching the point of actual fusion. With great energy of current, joints on iron-bars of over one-half inch diameter have been made in less than three seconds after applying the current, and with small wires the action is almost instantaneous.

During the passage of the current through the pieces, the pressure given to cause the union may be sufficient to produce more or less of an expansion or swell at the point of juncture, and by adjusting the pressure and temperature, the amount of such expansion may be governed to a nicety. It will also be evident that the temperature to which the pieces are heated, is most perfectly under control when suitable devices are employed to govern the flow of current. As a consequence of this, varieties of steel which are easily injured by excessive heating, or which will not bear hammering when hot, may be welded quite readily. Even very fusible metals, as lead, tin, zinc, may be welded if resin, or tallow, or chloride of zinc be used as a flux instead of borax. It has sometimes been asked, whether the electric current has any specific action in effecting the weld, other than its power to produce heat. It is certainly true that the molecular agitation which is produced by the current, and which manifests itself to us as heat, is more vigorous just at the melting surfaces than elsewhere, and that the current has the property of heating the whole section of metal uniformly by virtue of the fact that any cooler line of particles has, as

a result of being cooler, a less resistance than the hotter portions, and at once receives an undue proportion of the current passing, which, developing heat, soon brings the cooler particles to the same temperature as that of the other parts of the abutted section of the bars.

Very accurate work can, of course, be done when the clamps are kept in perfect line, or when the abutted surfaces are held in correct relative positions during the passage of current.

The results obtained in the application of electric welding to the various metals, promise to be of great practical importance. While ordinarily it has been the exception that metals weld readily, with the electric method no metal or alloy yet tried has failed to unite with pieces of the same metal, and the trials have included most of the metals commonly known—such as wrought iron, mild steel, tool steel; special steels, such as Mushet steel, and even cast-iron joints also being made between these different varieties of iron. Copper and its alloys, brass, bronze, german silver, etc., silver, pure and alloyed, gold, likewise, platinum, zinc, tin, lead, aluminium. The list is being extended as time and facilities permit.

Joints between different metals or alloys are often easily produced if their physical properties are not too unlike. Copper, brass, german silver, steel and iron, can be united one to the other, and in some cases the joints are of remarkable firmness and strength. I will close the present paper with a list of possible extended applications of the process in the arts, which is, of course, subject to extension in the future.

(1.) Joining wires, or bars, end to end, whether round, flat, square or polygonal in form. Under this heading would come making of long lengths of wire for telegraph and telephone line work, and joining small sections of wire into one length as in the construction of electrical apparatus. The specimens exhibited show varieties of such work.

Very large bars of iron or steel may, it is believed, be welded when the power of the apparatus is proportionately increased. The operation is undoubtedly economical of heat, because the heat used, whether obtained from steam or water-power indirectly, is concentrated just where it is needed for the work and is perfectly regulable. With large pieces, a saving of loss of heat by radia-

tion and convection to the air may be effected by applying a covering or shield lined with a non-conductor of heat, and made in sections to fit over and enclose the work, and either resting on it or kept out of contact as the case may be.

Examples of the welding of bars end to end appear in *Fig. 7* which is taken from a photograph of bars of iron, steel, copper, brass, zinc, lead, etc. Some of the bars, *19*, *20* and *21*, have been bent after welding. Bar *2* is composed of iron, copper and brass. Bar *3* is of copper, but has been hammered out flat at the weld.

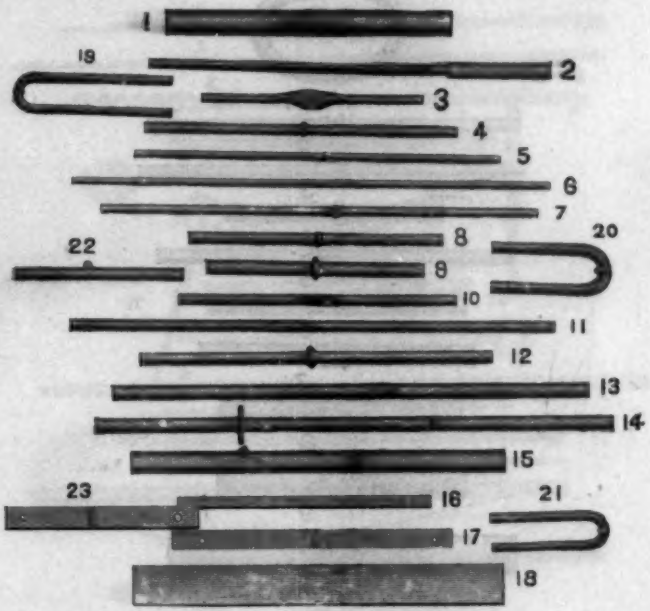


FIG. 7.

Bars *16*, *17*, *18* and *23* are square or rectangular in section. Bar *15* is composed of two pieces of cast iron welded together and the resulting bar in turn welded to a wrought iron piece.

(2.) Tubes and hollow forms of various metal may be welded together with facility, and it would be quite within the bounds of easy practicability to lay welded lines of wrought-iron or mild-steel, or even cast-iron pipe, with few or no screw joints. A small wire may convey the current to the place where the work is to be done, and the induction apparatus may be mounted so as to be portable. As the joining of lead pipes is effected with ease, a

soldered or wiped joint need no longer tax a plumber's skill. With wrought-iron pipe, the joints can be pressed or hammered, while the heat is maintained by the current. The specimens here shown give some idea of the work accomplished. *Fig. 8* represents the appearance presented by tubes of lead, brass, copper and iron in which a butt weld exists. Some of the joints have been hammered during the welding. *No. 1* is a lead pipe bent at *W* after welding.

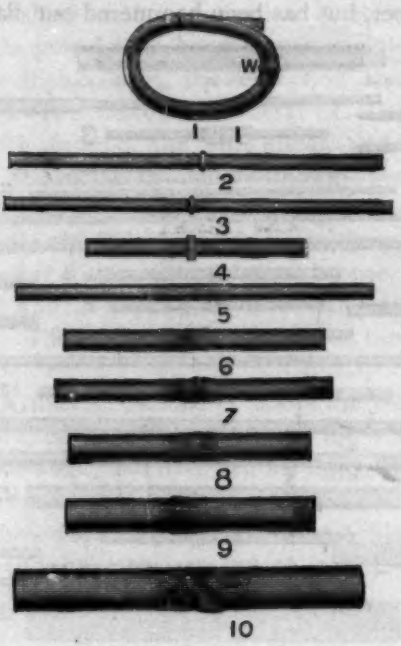


FIG. 8.

(3.) Endless hoops or rings, such as wheel, ties, barrel and tank hoops, band saws, chain links and chain, endless wire cables, etc., may be easily made or mended. Some examples of such work are here shown; one of the most notable of which is a piece of chain, all the links of which have a double electric weld; or, in other words, the links are made of two ∪-shaped pieces welded together at both ends simultaneously. One of the links is made of such pieces with a central cross-bar inserted and all welded together, the said bar dividing the link at its centre.

(4.) Making and repairing steel and iron, or other metal articles, such as screw bolts, taps, drills, knives and cutting instruments. There is an endless variety of this work, which can be materially assisted or simplified by electric welding. Bolts are lengthened or shortened as desired; taps, drills, augers, bits, reamers, etc., are in like manner lengthened. Poorer steel may be used for the body of a tool, and a better for the portion which forms the cutting edge. Lathe tools, worn or shortened by use, may be pieced out with facility. Different diameters of steel bar can be united readily, so

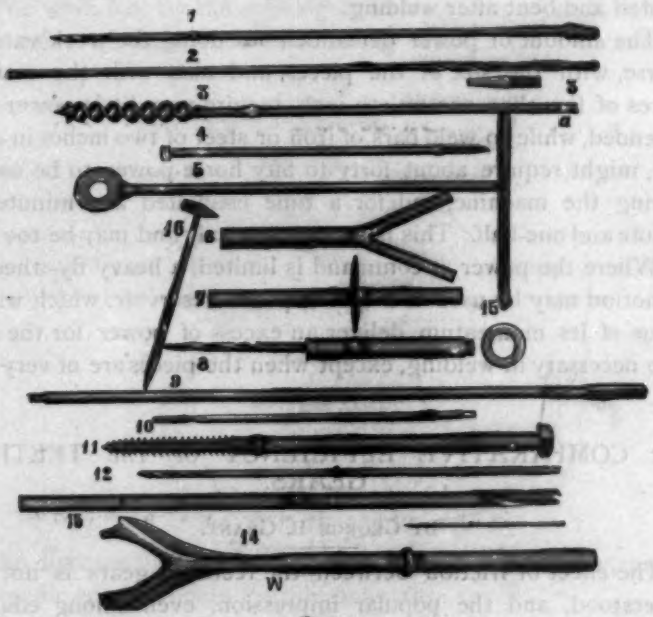


FIG. 9.

as to save forging and save material. Very delicate work, as in jewelry, may be effected. The construction and repair of delicate tools and appliances can be facilitated in many cases.

Fig. 9 is taken from a photograph of pieces typical of tool work. *Nos. 1, 3, 4, 9, 10, 11, 12* and *13*, are tools, as taps, drills, etc., lengthened by insertion of pieces. *No. 5* is a washer welded edgewise to a bar. *No. 6* is a fork composed of three pieces welded. *No. 7* is a steel disc welded in between two bars of iron. *No. 8* is a small twist drill welded to a taper shank of large diameter, the weld being made in the smaller section piece.

Specimens here presented show how readily small work is done, and I may refer to the fact that broken tools are easily mended without in many cases taking them out of their handles. This is instanced in the case of pen-knives, which are provided with new blades welded to the stumps without taking them out of the handle, and though the stumps project out not more than one-eighth inch. As evidence of the strength of the union effected between the pieces, I call attention to the numerous examples in copper, iron, etc., in which the specimens have been violently twisted and bent after welding.

The amount of power demanded for doing the work varies, of course, with the size of the pieces, and also with the material. Wires of less than one-fiftieth inch require very little power to be expended, while to weld bars of iron or steel of two inches in diameter, might require about forty to fifty horse-power to be used in driving the machine, and for a time estimated at a minute to a minute and one-half. This is an estimate only and may be too high.

Where the power at command is limited, a heavy fly-wheel set in motion may be used as a sort of power reservoir, which will, by virtue of its momentum deliver an excess of power for the short time necessary in welding, except when the pieces are of very large size.*

The COMPARATIVE EFFICIENCY of the TEETH of GEARS.

By George B. Grant.

The effect of friction between the teeth of gears is not well understood, and the popular impression, even among educated engineers, concerning the comparative efficiency of the two forms of teeth in common use—the involute and the cycloidal—is that the latter is much the most economical, and, therefore, much better adapted for use for the transmission of heavy-power.

This impression is entirely wrong, the reverse of the provable facts, and it is based not entirely on fancy but partly on the teaching of authorities that are undoubtedly competent.

It is with no small feeling of timidity, that I venture to contradict the declared and apparently proved opinions of such high

* [The Committee on Publications is indebted to the *Electrical World* for the use of several of the illustrations accompanying Prof. Thomson's paper. W. H. W.]

authorities as Reuleaux, Herrmann and others, and I would not dare to assert a contrary view if I did not feel able to prove it, by evidence that will bear the closest examination. I will give the demonstration in great detail, so that it can be followed by any one who is familiar with the common processes of analysis.

By the work done by a gear wheel, I mean the work done by the friction of sliding between the teeth. I shall leave out the small rolling friction between the teeth, and I shall not consider the friction of the shaft bearings.

The work lost by the rubbing of two surfaces on each other is the product of the normal force acting between the two surfaces,

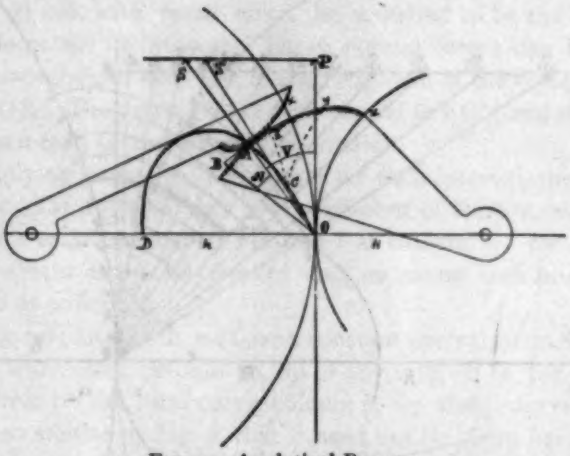


FIG. 1. Analytical Process.

by the distance through which the resistance is overcome, and by the coefficient of friction for the material in use.

To determine the work done by a pair of gear teeth, we must determine these three factors or their product, and this may be done in two different ways: by a graphical process, and by an analytical method. The two processes are entirely independent of each other beyond the given premises, and their agreement upon a common result is a substantial proof of the accuracy of both.

Graphical Process.—In *Fig. 1*, the two tooth curves have rubbed upon each other, while the point of contact between them has moved from C to A on the line of action, $O\,A\,D$, and they have done work that is the product of the coefficient of friction, f, by the difference, zy, of the lengths of the curves that have passed the

point of contact, and, for graphical purposes, of the average force, S', that has acted between the two teeth.

If we make a drawing, showing the two teeth in several positions, preferably at equal intervals of their action, we can determine the work done within the limits of each interval by multiplying together the factors as found by measurement. The total work done between any two points is the sum of these products for all the intervals between the points.

In *Fig. 2*, this process is applied to an exaggerated example of a pair of cycloidal teeth. The gears, with radii k and h, have ten

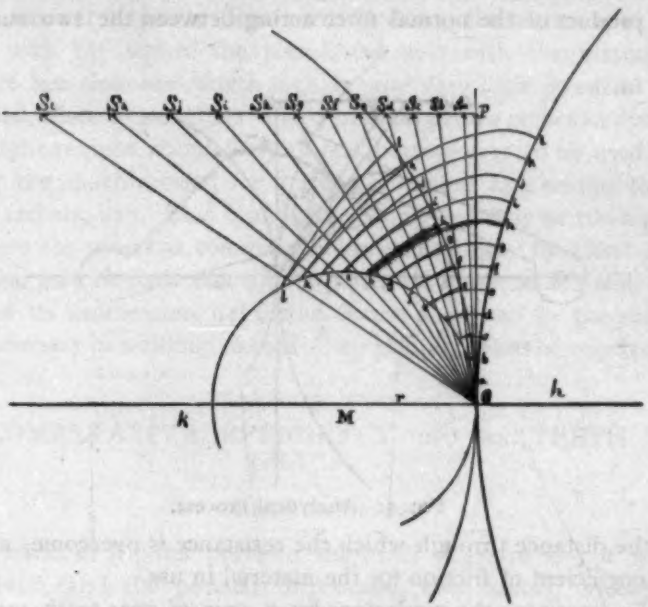


FIG. 2. Graphical Process.

and twenty teeth, the tangential force, OP, between the two gears is assumed to be constant and unity, and the coefficient of friction is assumed to be one-tenth. The describing circle, with radius $OM = r$, has three teeth, so that a gear of six teeth would have radial flanks and be the base or smallest gear of the interchangeable set to which the two gears belong.

The pitch and describing circles are divided into equal intervals, Oa, ab, bc, etc., of one-twelfth of the whole tooth arc, or circular pitch, Ol, commencing at the line of centres, and the work done over each of these small intervals is to be determined.

Make a templet of an epicycloid on the gear h, and of a hypocycloid within the gear k, and draw curves from each of the divisions of the pitch lines. Each pair of curves should meet on the corresponding division of the describing circle. Measure the differences between the lengths of these curves (see column 2 of the table), and by subtracting each total difference from the next larger, find the partial length of curve passed over during each interval, as tabulated at column 3.

Draw a line at an arbitrary distance, representing unity, from the line of centres and parallel with it, and draw lines, OSa, OSb, OSc, etc., through the centres of the intervals. The length of each line (column 4) can, with small error, be assumed to be the average normal force for its interval. These normal forces can be very easily computed, for each one is the reciprocal of the cosine of the angle POS. The angle for the first normal is $2\frac{1}{2}°$, and there are $5°$ between each of the following normals:

Multiplying together the normal for each interval, the partial curve for that interval, and the coefficient of friction, we obtain the loss for each interval as tabulated at column 5. By summation we obtain the total loss to and including each interval, as tabulated at column 6.

For the involute tooth, we have a constant normal force, $S = 1{\cdot}15$, the total work done, column 10, up to any interval is the product of that force by the total curve, column 9, for that interval. The figure is so similar to *Fig. 2*, that it need not be given here.

The graphical process will determine the general result, and show that while the two curves are substantially equal in efficiency, the advantage is a very little in favor of the involute. If we wish a precise comparison between these two curves, no graphical process can be used, and we must resort to analysis.

Analytical Process.—In *Fig. 1*, the two tooth curves are odontoids of any possible form, and they will secure a uniform velocity ratio between the pitch lines. They slide on each other, the point of contact moving along the line of action, $O\,A\,D$. At any time they are at a distance $O\,A = b$ from the pitch point, O, and are pressed together with a normal force, S, which is equal to the constant tangential force, P, divided by the cosine of the angle of obliquity,

$P\,O\,A = V$, and this normal force is always in the direction of the pitch point O.

While the normal, $O\,A$, turns through an elementary angle, the arc of which is $d\,V$, the two curves will rub on each other over an elementary distance, $A\,B = O\,A \cdot d\,V = b \cdot d\,V$, and they will do the elementary work

$$d\,W = f\,P \cdot \overline{A\,B} \cdot S \cdot = f\,\frac{P}{\cos\,V} \cdot b \cdot d\,V.$$

At the same time the wheel h will turn through the elementary angle, the arc of which is

$$d\,x = \frac{k}{k \pm h}\,d\,V$$

in which the positive sign is for external, and the negative sign is for internal contact.

Therefore, we have the total work done by friction, while the wheel h is turning through an angle, the arc of which is x.

$$W = f\,P \cdot \frac{k \pm h}{k} \int_0^x \frac{b\,d\,x}{\cos\,V}$$

and this cannot be carried further until we know the form of tooth curve to be used, and can determine b and $\cos\,V$ in terms of x.

First take the involute tooth.

The distance $O\,A = b$ is equal to $h\,x \cdot \cos\,V$, and we have the total work done

$$I = f\,P \cdot \frac{k \pm h}{k}\,h \int_0^x x\,d\,x,$$

which integrates to

$$I = \frac{f\,P}{2} \cdot \frac{k \pm h}{k}\,h\,\frac{x^2}{2},$$

or, if we use the arc on the pitch line, $w = h\,x$, we have

$$I = \frac{f\,P}{2} \cdot \frac{k \pm h}{k\,h}\,w^2$$

for the value of the work done by the friction of involute teeth while moving from the pitch point over any arc, w, on the pitch circle.

It is a singular fact that this loss of power is the same for all

values of the angle of obliquity. All involute systems are equal in efficiency, without regard to the angle of obliquity.

Then take the cycloidal tooth.

We have $b = 2\,r\,.\,sin\,\frac{h}{2\,r}\,x$, and $cos\ V = cos\,\frac{h}{2\,r}\,x$, giving the total work.

$$E = f\,P\,.\,\frac{k \pm h}{k\,h}\,2\,r\int_{0}^{x} tan\,\frac{h\,x}{2\,r}\,d\,x,$$

which integrates to

$$E = -f\,P\,.\,\frac{k \pm h}{k\,h}4\,r^2\ nat\ log\ cos\ \frac{w}{2\,r},$$

the value of the total work of a pair of cycloidal teeth.

To compare the cycloidal with the involute tooth for the same arc of action from the pitch point, divide E by I.

$$\frac{E}{I} = \frac{8\,r^2\ nat\ log\ cos\,\frac{w}{2\,r}}{w^2}.$$

As this is unity for $w = O$ and greater than unity for any finite value of w, it follows that the efficiency of the involute is mathematically superior to that of the cycloidal curve, in all cases and under all circumstances, without regard either to the angle of obliquity of the involute, the size of the describing circle of the cycloidal curve, or the arc of action, and provided only that the comparison is made over the same arc of action. (See column 13 of the table.)

In both of these formulæ it is seen that h and k can exchange places without affecting the result for external contact, and therefore the work done is the same, for the same arc of action, on both sides of the line of centres, the tangential force being constant.

For a comparison between external and internal gears, we have

$$\frac{A}{B} = \frac{I\ or\ E\ Ext.}{I\ or\ E\ Int.} = \frac{k + h}{k - h}$$

so that the internal gear is much the most economical, particularly when the two gears are nearly of the same size.

When $k = 2\,h$ we have $\frac{A}{B} = 3$. That is, if the internal gear is twice the size of its pinion, the work lost is but one-third of that lost when both gears are external.

Small improvement can be made by putting a small pinion inside, rather than outside of a large gear, as is often done at great expense on boring mills and large face plate lathes. A six-inch pinion and a six-foot gear will give $\frac{A}{B} = 1{\cdot}18$ an advantage of no great value.

It is seen from the above that the work being done increases very rapidly with the arc of action; with the square of that arc in the case of the involute, and in a still greater proportion for cycloidal teeth, and hence that arc should always be made as small as possible.

Strength should be secured by a wide face rather than by a large tooth, for the face of the gear has no influence on its efficiency.

The two formulæ for E and I can be very easily applied to any particular example, and the results obtained much more quickly, as well as more accurately than by the graphical method.

For application to the given example, where $h = 10$, $k = 5$, $f = l$, and $P = 1$, we have

$$E = 6{\cdot}2170\ [C - \textit{log cos}\ (5\ n)^\circ]$$
$$I = \ {\cdot}01028\ n^2$$

in which n is the number of any interval, C, is the characteristic with the sign changed, and *log cos* contains only the mantissa of the common logarithmic cosine of $5\ n^\circ$.

It is seen from the tabulated value of E and I obtained by computation, columns 7 and 11, that the graphical and analytical processes agree very closely, the errors being shown by columns 8 and 12, as before stated, this agreement is a strong indication of the accuracy of both.

Prof. Reuleaux* finds that the two curves are exactly equal when compared over the same arc of action, and Prof. Hermann† finds the same result by a different process. In both cases the result was arrived at by making an approximation, for reasons not given but probably to simplify the work.

If the actual determination of the work done is the end in view, the approximations can be allowed, as the result is then close enough for all practical purposes. But, if the object is a close comparison between the two curves, the slightest difference must be accounted for, and neither Reuleaux's nor Herrmann's formulæ will answer the purpose.

Herrmann remarks, "It is evident, moreover, that the friction of involute teeth will be somewhat greater than that of cycloidal teeth, the angle γ being smaller for the former than for the latter."

This may be "evident," but it is not provable, and the statement that the angle γ, which is the complement of the angle of obliquity, is smaller for the involute, is not correct. Up to the half tooth point it is so, but beyond that point the reverse is true. At the half tooth point the two forms always have the same angle of obliquity if they belong to interchangeable sets which have the same base gear.

Further, it does not follow that the work of friction is the greater when the angle of obliquity is the greater, for the work of friction depends on two variable factors, the normal pressure, which indeed increases with that angle, and the length of the curve that is rubbed over. Within the half tooth point this curve is the shortest for the involute, so that the work done is the smallest although the other factor is the greatest.

As Herrmann states, "This difference is insignificant for the tooth profiles ordinarily employed," but the general impression, which it is the object of this paper to contradict, is that the difference is very significant and in favor of the cycloidal tooth.

Reuleaux goes further, and, after finding that the two curves are exactly the same for the same arc of action, gives several practical

* *Transactions of the American Society of Mechanical Engineers*, vol. viii, 1886. The result, without the demonstration, is also given in *Reuleaux's Konstrukteur*, § 213.

† Klein's translation of Herrmann's revision of *Weisbach's Mechanics of Engineering and Machinery*, vol. iii, § 79.

examples, which show the involute to be decidedly inferior, the difference being from sixty to eighty per cent.

This result is correct for the conditions of Reuleaux's examples, but it seems to me that those conditions are not correct if the object is to compare the two curves, for he does not take them on the same terms. He takes the involute with a long arc of action, and compares it with a cycloidal tooth having a short arc, and of course the involute is then inferior.

EXAMPLE FOR $k = 10$ $k = 5$ $r = 1{\cdot}5$ $f = {\cdot}1$ AND $P = 1$.

Interval.	Cycloidal Teeth.							Involute Teeth. Obliquity, 30°. $S = 1{\cdot}15$.				
					Total Work.				Total Work.			
	Total Curve	Partial Curve	Normal Force.	Partial Work	Graph	Anal's	Error	Total Curve	Graph	Anal's	Error	$\frac{E}{I}$
1	·010	·010	1·0009	·0010	·0011	·00103	·0001	·02	·0023	·00103	·0013	1·008
2	·035	·025	1·0087	·0025	·0036	·00413	·0005	·04	·0046	·00411	·0005	1·004
3	·085	·050	1·0243	·0510	·0086	·00937	·0008	·08	·0092	·00924	0	1·013
4	·155	·070	1·0485	·0735	·0160	·01679	·0008	·15	·0173	·01645	·0008	1·021
5	·245	·090	1·0824	·0975	·0257	·02656	·0009	·22	0254	·02570	·0003	1·033
6	·355	·110	1·1274	·1240	·0382	·03884	·0006	·32	·0370	·03701	0	1·049
7	·485	·130	1.1857	·1540	·0536	·05386	·0003	·44	·0508	·05038	·0004	1·069
8	·630	·145	1·2604	·1825	·0718	·07196	·0002	·57	·0658	·06580	0	1·094
9	·790	·160	1·3563	·2170	·0935	·09357	·0001	72	·0831	·08328	·0002	1·124
10	·965	·175	1·4802	·2590	·1194	·11932	·0001	·90	·1039	·10281	·0011	1·161
11	1·150	·185	1·6426	·3040	·1498	·15008	·0003	1·09	·1259	·12440	·0015	1·206
12	1·350	·195	1·8615	·3630	·1861	·18715	·0011	1·30	·1501	·14805	·0020	1·264
1	2	3	4	5	6	7	8	9	10	11	12	13

The work done increases rapidly with the distance of the point of contact from the line of centres, and the result of Reuleaux's method is to compare one curve that is at work a considerable distance from the line with another that is nearer to it.

This is clearly shown by the figures of Reuleaux's comparative examples, for in each case the losses are almost exactly proportional to the arcs of action.

For the purpose of comparison, the two teeth should be taken under precisely the same circumstances, and they should commence work and stop work together. They should have the same arc of action rather than the same addendum, for the addendum has very

little to do with the gear except by its effect on the maximum arc of action.

When taken under similar circumstances, involute and cycloidal gear teeth are practically equal with regard to the work done by friction, the difference being always slightly in favor of the involute.

Boston, Mass., February 21, 1887.

TURBINES.

By Irving P. Church, C. E.,
Assistant Professor Civil Engineering, Cornell University.

(*Concluded from Vol. cxxiii, page 331.*)

(1.) A *uniform* motion (constant velocity $= \omega r$) in the arc of a circle from O to O'.

(2.) An *accelerated* motion along the small arc $O B$ of the pipe; the acceleration of this motion being $= \frac{d v}{d t}$, its initial velocity $= v$, its final velocity $= v + d v$.

If the small arc $O B$ of the pipe remained parallel to itself, while O was passing to O', the particle would be at E', the further corner of the parallelogram formed on $O O'$ and $O B$, at the end of $d t$, and the two component motions just mentioned would be the only ones, the resultant motion being then $O E'$; but on account of the rotation of the pipe about c, the particle is really at B', at the end of $d t$, requiring us to compound with $O E'$ a third motion, $E' B'$ or $O E$, which may be regarded as rectilinear (being a small arc with centre at O'), and is, of course, accelerated, having an initial velocity of zero at O, and a final velocity of $p d t$ (p denotes the unknown acceleration of this motion and is regarded as constant during $d t$), and hence,

(3.) A uniformly accelerated rectilinear motion from O to E, normal to pipe curve at O, with initial velocity of zero (and whose acceleration p is thus found: Since $O E = E' B' = \overline{O B'}\, \omega\, d t = v\, d t\, \omega\, d t = \omega\, v\, d t^2$, and since the distance described in a uniformly accelerated motion with initial velocity = zero is equal to acceleration $\times \frac{1}{2}$ (time)^2, we have $\omega\, v\, d t^2 = \frac{1}{2}\, p\, d t^2 \therefore p = 2\, \omega\, v$).

The only (horizontal) force acting on the particle at this instant is the pressure (call it N) of the side of the pipe and acts along $C'O$, but is not shown in the figure; in magnitude and direction, however, it must be equivalent (*i. e.*, must be the resultant) of any imaginary system of forces capable of producing the three component motions just mentioned. To determine an imaginary equivalent system, we have only to apply to the three component motions the following well-known theorems for the dynamics of a "material point," or small particle (based directly upon Newton's laws):

Theorem A.—If the particle is moving in a right line with an accelerating velocity, the resultant force must act along that line, in the same direction as the acceleration, and have a magnitude = mass of particle × acceleration.

Theor. B.—If the particle is moving with uniform velocity in a curved path, the resultant force at any instant must be directed toward the centre of curvature and have a magnitude = mass of particle × square of velocity ÷ the radius of curvature.

Theor. C.—If the particle is moving with accelerating velocity in a curved path, the resultant force at any instant is equivalent to two forces, viz., a tangential force = mass × acceleration of the velocity (in same direction as the acceleration), and a normal force (*toward* centre of curvature) = mass × square of velocity ÷ radius of curvature.

Our imaginary system of forces, then, equivalent to the force N, or pressure of the side of pipe against the particle, is constructed as follows:

The component motion, No. 1, can be produced by a force along $OC = P_1 = M(\omega r)^2 \div r = \omega^2 Mr$ (in which M denotes the mass of the particle), by Theorem B, see *Fig. 6* for positions of forces.

Motion No. 2, by Theorem C, can be produced by the two forces P_2, normal to pipe, $= Mc^2 \div \rho$, and the tangential force $P_2' = M \times \text{acc.} = M(dc \div dt)$; while motion No. 3, by Theorem A, can be produced by a force $P_3 = M \times$ acc., *i. e.*, $P_3 = 2M\omega c$ (see above) along OE, *Fig. 6*.

Denote the angle $C''OC$, between the two radii of curvature, by μ (Mr. Woodbridge's γ); then, since the real force acting, N, acts in the line $C''OE$ normal to side of pipe, and is equivalent to the imaginary four forces, P_1, P_2, P_2' and P_3, of *Fig. 6*, it must

be equal to the algebraic sum of their components along $C'OE$, *i. e.*,

$$N = M\left[\frac{c^2}{\rho} + \omega^2 r\cos\mu - 2\omega c\right] \qquad (g)$$

which is the value of the pressure of the pipe against the particle at this instant. In *Fig. 6*, N is supposed to have the same direction as P_2', but if a negative result is obtained from equation (g) in any particular case, N must have the direction of P_2.

[With *Fig. 6*, as drawn here, a negative N from equation (g) indicates that the pipe is doing work upon (*i. e.*, transmitting energy to) the particle, *i. e.*, is accelerating the absolute velocity of the particle; while a positive value shows the converse, that the particle is doing work upon the pipe and its connections (this energy, however, is spent in work external to pipe, not in accelerating the rotary motion of the pipe, for ω by hypothesis is constant throughout this discussion). This is similar to the distinction between the modes of working of a centrifugal pump and a turbine. The former does work upon the water which is pumped, with a large value for the wheel-rim velocity; while the latter, with its connected machinery, is driven *by* the water, with a wheel-rim velocity regulated to a moderate value for best effect.]

Again, the real force N has no component tangent to the side of pipe OB, and hence the algebraic sum of the components of the imaginary forces perpendicular to $C'OE$ must be zero; *i. e.*,

$$M\frac{dc}{dt} - \omega^2 Mr\sin\mu = 0$$

But, see *Fig. 6*, $\sin\mu = \overline{BK} \div \overline{OB} = dr \div c\,dt$, whence, by substitution,

$$M\left[\frac{dc}{dt} - \frac{\omega^2 r\,dr}{c\,dt}\right] = 0. \qquad (h)$$

Reducing (h), we obtain

$$c\,dc = \omega^2 r\,dr,$$

which contains but two variables, c and r, already separated. Integrating between some initial point 1 of the pipe, and any other, we have

$$\int_{c_1}^{c} c\,dc = \omega^2 \int_{r_1}^{r} r\,dr\,;\ \text{or, } c^2 - c_1^2 = \omega^2(r^2 - r_1^2) \qquad (k)$$

showing that c is a function simply of the distance from the axis, being independent of the form of the pipe.

Fig. 7.

We may now utilize the imaginary system of forces in *Fig. 6*, in considering the absolute motion, in time dt, of the small prism, or lamina, of water in *Fig. 7*, included between two cross-sections of a turbine-channel, a distance $OB = c\,dt$ apart. Let p denote the mean pressure per unit-area on the face CO, then $p + dp$ is the pressure on DB. Let F denote the area of each of these faces. The real forces acting (horizontal), are the Fp and $F(p + dp)$ just mentioned, and the pressures from the partitions; these latter having no components tangent to OB. The sum of the components along OB of the real forces must equal the corresponding sum for an imaginary equivalent system like that shown in *Fig. 6*. The latter sum we have (in form) in the left hand member of equation (h), hence

$$dM\left[\frac{dc}{dt} - \frac{\omega^2 r\,dr}{c\,dt}\right] = -F\,dp$$

But now the mass, dM, is the mass of the small lamina, and $= F\overline{OB}\gamma \div g$, *i. e.*, $= F(c\,dt)\gamma \div g$, whence, after substitution and reducing, etc.,

$$\frac{1}{g}\,c\,dc = \frac{\omega^2}{g}\,r\,dr - \frac{1}{\gamma}\,dp \qquad \text{(k)}$$

in which the three variables, c the relative velocity, r the radius vector, and p the internal liquid pressure, are separated.

Now the flow being "steady," and considering the whole stream from entrance (position 1) to exit (position n) of the channel to be subdivided into equal small laminæ, then, in any one dt these

laminæ simultaneously advance, each into the position (in the pipe, or channel, not in space), which the lamina just ahead occupied at the beginning of the dt, and each lamina thus assumes the same values of c, r, and p, which its predecessor had, dt before. Hence, if we write out an equation like (k) for each lamina between 1 and n, and sum corresponding terms, we obtain

$$\frac{c_n^2}{2g} - \frac{c_1^2}{2g} = \frac{(\omega r_n)^2 - (\omega r_1)^2}{2g} - \frac{p_n}{\gamma} + \frac{p_1}{\gamma} \qquad (l)$$

which is equation (6) of Mr. Woodbridge's article, and may be called Bernoulli's theorem for steady flow through a uniformly rotating horizontal pipe.

Thinking it will not be out of place in this connection, the writer wishes to offer some criticisms on parts of articles in this journal by Prof. Wood and Mr. Frizell, in which the problem of the friction-less particle in a horizontal tube rotating with uniform angular velocity about a vertical axis is considered. On p. 419, JOURNAL FRANKLIN INSTITUTE, June, 1884, Prof. Wood presents an amended version of Weisbach's treatment for finding the law of change of the relative velocity, in which he states that the acceleration of the relative velocity is just the same as if due solely to the component along the tube of a force $\omega^2 M r$, equal and opposite to the radial force which *would* be exerted on the particle by the tube, *if* the former, relatively at rest, were to accompany the tube in its rotation, *i. e.*, with the same angular velocity, ω, as the tube.

This is doubtless true, since the relation $c\,dc = \omega^2 \rho\, d\rho$, which it implies, can be proved by straight-forward fundamental methods; but is it not too much to ask of a student, to grant such a postulate? It may seem reasonable to him, perhaps plausible, but the fact that the angular velocity of the particle after release from the imaginary constraint is not ω, may arouse doubts in his mind, as it did in that of Mr. Frizell (JOURNAL FRANKLIN INSTITUTE, August, 1883, p. 92); while again, from Prof. Wood's statement, "the component normal to the tube will simply produce a pressure against the side of the tube," he will infer that that pressure must therefore $= \omega^2 M \rho \cos\theta$. But this latter relation is not true, as the student would doubtless conclude after a little thought, since the tube may have such a form that the particle exerts no pressure (horizontally) against it, and at points where $\cos\theta$ is not zero.

The instructor might then reply, perhaps: "Yes; but the pressure against the tube depends on other agencies as well;" and the student could rejoin: "But how am I to know that these 'other agencies' have no influence on the relative velocity?"

On the whole, then, may we not conclude that even this amended form of Weisbach's demonstration is altogether too artificial and unsatisfactory (although so brief in its algebra) for presentation to a beginner in mechanics? If any fictitious forces are to be called into play, is it not better to employ such a complete system, like that in *Fig. 6*, of this article, as may be easily proved to be the full equivalent, in *all* respects, of the real force acting, viz., the unknown wall-pressure?

In the JOURNAL FRANKLIN INSTITUTE, for July, 1884 (p. 29), appeared one article by Mr. Frizell on the discharge of turbines, to which the present writer would have replied long ere this, if by some mischance he had not missed seeing that number at the time, and thought afterward that he had examined all the numbers of that year. Two months ago in a bound volume in the University Library it casually came to his notice.

Weisbach's fictitious "centrifugal force" $P = \omega^2 M r$ (see p. 93, JOURNAL FRANKLIN INSTITUTE, August, 1883), Mr. Frizell proposes to replace by the following,

$$P = M\left[(\omega - \omega_1)^2 r - v\right] \qquad \text{(m)}$$

(p. 31, JOURNAL FRANKLIN INSTITUTE, July, 1884), in which ω and ω_1 are the respective angular velocities of the wheel, and of the particle with respect to the wheel, r the radial distance of the particle from wheel axis at any instant, v the radial component of the absolute velocity of the particle, and M the mass of the latter. Of these quantities, ω_1, r, and v are variable, M and ω constant. (In the August number, 1883, Mr. Frizell upheld Weisbach in the statement that $P = \omega^2 M r$ for a radial tube, whereas equation (m) would reduce to $P = \omega^2 M r - M v$ in such a case.)

The most prominent feature of this formula (and one which Mr. Frizell must have noticed ere this), that it is not homogeneous, *i. e.*, that in the bracket we have combined, by algebraic addition, two quantities of *unlike kinds*, for $(\omega - \omega_1)^2 r$, is an *acceleration*, while v is a *velocity*. This incongruity alone shows it to have no sound basis in theory, but as Mr. Frizell seems to place more

reliance on particular cases than in general demonstrations, let us apply one or two tests to equation (m) as applicable to the problem of the particle in the rotating tube, or top.

First, algebraically, suppose the tube straight and radial, and at rest; *i. e.*, $\omega = 0$, $\omega_1 = 0$; while v becomes the absolute velocity, which we may call w. Equation (m), then, would assert that the particle is under the action of a force, acting inward along the tube, of a value

$$P' = -Mw.$$

But if any such force exists (and the incongruity above mentioned is now quite apparent; Mw is momentum, not force), the motion along the tube must be retarded; but we know practically that in a straight horizontal tube at rest there is no force to change the velocity of the particle (friction aside).

Secondly, a numerical test. As is well known, any formula in pure mechanics, properly based on sound principles, while as yet in symbolic form (*i. e.*, containing no numerals but abstract numbers, like the 2 in $v = \sqrt{2gh}$ for a falling body) will give identical results whatever system of units be employed; (the equation may then be called *homogeneous*). Now equation (m), if true, should endure such a test; for as yet no numerical substitution has been made which commits us to any special system of units (Mr. Frizell's announcement about the foot and second a few lines before is premature; he surely would not claim that $v = \sqrt{2gh}$, for example, is true for the foot and second, and not for the metre and minute).

Let us take $(\omega - \omega_1) = 4$ radians per second (the radian being the unit of π-measure, or circular measure, being the angular space of which it takes 6·28 .... (2π) to make a full revolution; the term, feet per second for angular velocity, used by Mr. Frizell, is entirely out of place since angular space is independent of units of length); $v = 12$ feet per second; $r = 1$ foot; and the weight of the mass $= 0{\cdot}644$ pounds.

Adopting the foot-pound-second system of units, in which $g = 32{\cdot}2$, and hence substituting the above numerals in equation (m), we obtain

$$P = \frac{0{\cdot}644}{32{\cdot}2}\left[4^2 \times 1 - 12\right] = 0{\cdot}08 \text{ pounds.}$$

Now changing to the foot-pound-*minute* system, in which $g = 32{\cdot}2 \times 60^2 = 115920$· we substitute $(\omega - \omega_1) = 4 \times 60 = 240$ radians

per minute, $v = 12 \times 60 = 720$ feet per minute, r and the weight as before, and obtain

$$P = \frac{0{\cdot}644}{115920}\left[240^2 \times 1 - 720\right] = 0{\cdot}316 \text{ pounds},$$

which is by no means identical with the 0·08 pounds previously found; the natural result of using a non-homogeneous equation.

In the turbine computations, taking experiment No. 21, the "common theory," without any considerations of friction, gives the volume discharged per second as

$$Q = 161{\cdot}87 \text{ cubic feet per second},$$

(derived from equation (16), p. 340, JOURNAL FRANKLIN INSTITUTE, May, 1884), the experimental result being 139·9 cubic feet per second. Mr. Frizell's formula for Q is that of the common theory with the "centrifugal term" replaced by a quantity based on the erroneous relation in equation (m), and without friction gives $Q = 152{\cdot}6$ cubic feet per second. If now the unit of time be changed to the minute, equation (16) of the writer gives

$$Q = 9712{\cdot}20 \text{ cubic feet per minute},$$

a result identical with that first mentioned; while Mr. Frizell's formula, on account of its non-homogeneous term, will yield a *new result every time the unit of time is changed.*

By considering friction (in doing which it is curious to note that Weisbach's coefficients are adopted, based as they must have been on a comparison between Weisbach's theory and experiments) Mr. Frizell's apparent result $Q = 152{\cdot}6$ cubic feet per second, which is only ten per cent. in excess of the 139·9, is diminished to about five per cent. excess, which is finally abrogated by utilizing the rather remarkable assumption that if the sectional area of a guide passage (running full) is F and the "*velocity through F*" is $= c$, then the discharge through F is not $Q = Fc$, but *five per cent. less.*

Mr. Frizell's computations, then, simply amount to this: That, restricting its use to a definite unit of time, the common theory may be so modified by replacing the "centrifugal term" by an empirical expression, that by using Weisbach's mean coefficients for skin-friction head, and considering the loss of head due to impact at entrance, the computed discharge for the Tremont turbine will be about five per cent. greater than that observed in Mr. Francis' experiments.

Returning to the problem of the tube and the particle, another test which any one can easily apply for himself, to prove that the equation

$$c_2^2 - c_1^2 = v_2^2 - v_1^2 = (\omega r_2)^2 - (\omega r_1)^2$$

(p. 612, *Coxe's Weisbach*) is correct in the particular case when the path is a *straight line in space*, the particle not touching either side of tube, is this: Referring to *Fig. 2*, of this article, suppose $M N$ to be the straight absolute path, then the particle not touching either side of the tube will preserve its absolute velocity, w, unaltered, *i. e.*, w, at $M = w_2$ at $N = w$. Knowing the wheel velocity at M, $v_1 = \omega r_1$, and at N, $v_2 = \omega r_2$, construct parallelograms at M and N to determine the relative velocities, c_1, and c_2, as on p. 612, *Weisbach*. If this be done graphically, and the values of c_1 and c_2 scaled off, the relation $c_2^2 - c_1^2 = v_2^2 - v_1^2$ is easily verified by substitution. Or, by formulæ (and without numercial verification) if a_1 is the angle between w and v_1 at M, a_2 between w and v_2 at N, we have by trigonometry,

$$c_1^2 = w^2 + v_1^2 - 2\, w\, v_1 \cos a_1$$

$$c_2^2 = w^2 + v_2^2 - 2\, w\, v_2 \cos a_2$$

whence, by subtraction,

$$c_2^2 - c_1^2 = v_2^2 - v_1^2 - 2\, w\, (v_2 \cos a - v_1 \cos a_1)$$

But the length of the perpendicular from the wheel axis upon the right line, $M N$, is

$$r_1 \cos a_1 = r_2 \cos a_1$$

$$\therefore \omega r_1 \cos a_1 = \omega r_2 \cos a_2, \text{ or, } v_1 \cos a_1 = v_2 \cos a_2$$

whence, finally,

$$c_2^2 - c_1^2 = v_2^2 - v_1^2 \qquad Q\,E\,D.$$

It is, perhaps, hardly necessary to say that, although some of the writer's deductions have been stated in a very positive manner in this article, no discourtesy is intended; he is simply sure he is right, and "goes ahead." As to his discussion with Mr. Frizell, the burden of proof rests with the latter, since he (in August, 1883) first declared Weisbach's result in the purely theoretical problem of the top and the particle to be erroneous.

Ithaca, December 28, 1886.

ALUMINIUM AND ITS ALLOYS; WITH EXPERIMENTAL INVESTIGATIONS.

By Edward D. Self, Stevens Institute of Technology.*

(*Concluded from Vol. cxxiii, page 322.*)

In general, the ten per cent. bronze works much better and cleaner than brass, and takes a more beautiful polish which it retains longer. These properties make it eminently suited for philosophical and other instruments, as it not only takes a beautiful lustre, but under ordinary circumstances does not require to be shellaced.

The resistance of the bronzes to corrosion in sea and mine water does not seem to be well sustained. Water containing alkaline carbonates, however, did not noticeably attack the specimens tested. As it seemed best to prepare a solution that would contain the injurious elements usually found in mine waters, rather than employ a real mine water that might contain only some of the ingredients frequently found in such waters, the following solution was prepared:

Na Cl,	100 grams.
$Na_2 CO_3$,	100 "
$Fe_2 Cl_6$,	100 "
Alum,	100 "
$Ca Cl_2$,	100 "

These substances were dissolved and diluted to a litre and neutralized.

The salt water used was taken from the middle of the Hudson River, at high tide, as at that time the influence of the upper fresh waters was the least easily felt, and in reality appreciably nothing.

The alkaline solution was prepared by dissolving 500 grams of $Na CO_3$ in a litre of water. The pieces of metal used were strips of sheet metal containing about five square inches. They were all carefully buffed to remove the scale or oxide formed in rolling, and all traces of grease were removed.

When placed in the mine water solution the pieces of metal were quickly attacked and turned black, or gray with shining

* Graduation Thesis, 1886.

specks in a day or two. The bright specks appeared not only on the metal, but on the surface of the liquid also.

The following are the data:

Name.	*Mark.*	*First Weight.*	*Second Weight.*	*Loss.*
5 per cent.,	A_2	7·999 mgs.	7·329 mgs.	·670
7½ "	B_2	9·058 "	8·076 "	·982
10 "	C_2	9·9385 "	8·961 "	·9775

Time, 50 days.

In the cases of the first and second, above given, the pieces were bent to admit of placing them in a small beaker. On the final examination, it was found that the lower part of the bend, resting on the glass, showed a bright copper-colored surface, as though the pieces had been copper with a bronze plating, which was there destroyed. The pieces in this test were all thickly coated with carbonate of copper where they were exposed to the air. The surface of the liquid was also thickly covered with a green mass.

The specimens immersed in salt water gave the following results:

Name.	*Mark.*	*First Weight.*	*Second Weight.*	*Loss.*
5 per cent.	A_1	9·767	9·704	·063
7½ "	B_1	9·658	9·591	·067
10 "	C_1	10·227	10·154	·073

Time, 50 days.

The pieces were placed in a flat dish, and salt water added from time to time, to replace that lost by evaporation. The action was not very rapid, but a green scum was produced and finally settled on the pieces. The phenomena were similar to the mine-water test, but very much less marked. The solution of alkaline carbonate remained colorless, and the pieces were not visibly acted upon or changed.

TENSILE TESTS.

The ingot, already described, was again cut with a parting-tool to obtain a tension test piece of the maximum length possible; but even this was found to be too short to admit of proper securing, and the following expedient was adopted:

Wrought-iron bars about 4 inches long, with a diameter of 1¼ inches, and having an enlargement of about an inch in the diameter, extending about one-third the way from each end, were employed. A ⅞-inch hole was bored in one end of each piece and

a V-thread, with $\frac{1}{12}$ inch pitch cut in each, before removing from the lathe. The ends of the test piece were now cut with a diameter sufficient at the ends to admit of cutting a thread to fit the wrought-iron nuts already prepared. After screwing the bronze into the nuts and tightening only enough to insure that the threads were in contact throughout, the piece was placed in a Riehlé testing machine of a capacity of 40,000 pounds, and held in perforated chucks, and at the bottom of which was a ring or shoulder, to prevent the wrought-iron nuts from being drawn through. On each end of the test piece were screwed two micrometer screws, reading to $\frac{1}{10.000}$ inch, and abutting pieces, respectively. By employing the method of electrical contact, the extension was easily read to within two or three ten-thousandths of an inch. The axis of the specimen was very carefully made parallel to the direction of the pull to be applied, to eliminate all shearing stresses.

The following are the data derived from this test. Sets were taken occasionally.

Diameter of specimen, ·675 inches between fillets. Length between fine centre punch-marks at bottom of fillet, 7·66 inches.

Load Pounds.	*Micrometer I.*	*Micrometer II.*
150	1·1416	1·1735
2,000	{ difference, 55	}
3,000	{ " 25	}
4,000	1·1463	1·1804
Set 150	1·1407	1·1747
4,500	1·1455	1·1817
5,000	1·1460	1·1826
5,500	66	35
6,000	79	43
Set 150	1·1412	1·1756
6,250	1·1486	1·1849
6,500	93	54
6,750	1·1500	58
7,000	10	69
7,250	17	76
7,500	25	89
7,750	35	1·1908
8,000	46	20
Set 150	1·1478	1·1830
8,250	1·1565	1·1940
8,500	80	54

Load Pounds.	*Micrometer I.*	*Micrometer II.*
Set 150	1·1478	1·1830
8,750	1·1597	1·1981
9,000	1·1619	1·1986
9,250	36	1·2007
9,500	71	40
9,750	83	61
10,000	1·1720	96
Set 150	1·1549	1·1993
10,250	1·1785	1·2123
10,500	90	48
10,750	1·1823	73
11,000	58	1·2208
11,250	1·1908	40
Set 150	1·1681	1·2051
12,000	1·2035	1·2370
13,000	1·2255	1·2565
Set 150	1·2186	1·2540

At this point, the extension became so great as to indicate that nearly the maximum load had been applied. For this reason, the micrometer screws were removed, and the distances between the "centre-punch" marks measured occasionally, with fine pointed dividers and scale.

Load Pounds.	*Lengths.*	*Remarks.*
14,000	7·7 inches.	
16,000	7·8 "	
18,000	7·91 "	
19,750	. . . "	This load stripped the *wrought-iron* thread in nut, not injuring the bronze. The chucks of the machine were then brought closer together, and flat wedges with V-grooves substituted for the nut and collar.
20,160	. . . "	Ditto (other end).
20,160	8·1 "	Broke one of the steel-wedges horizontally; wedge about 4½″ x 2½″ x ½″ at smallest end.
23,160	. . . "	Specimen broke near fillet. The test took nearly five hours on account of the above unusual difficulties.

The piece, where broken, showed a much striated surface, and the fracture was fine and silky in appearance, and in this particular exhibited many characteristics of wrought-iron or low-grade steel.

The specimen, after fracture, showed many evidences of a high

ductility. An examination of the results of the test shows that the elastic limit, as in copper alloys generally, is ill defined. This is seen on reference to the curve of extensions given on the next page. The limit of elasticity is, however, at the point where the extensions suddenly increase for equal loads.

It has already been stated that the tenacity and good qualities of aluminium-bronze improve after several meltings.

This is shown by the results of some tests, subsequently made, of ten per cent. bronze, either melted but once or twice, or else when melted, badly chilled in casting. The specimens were already cast into approximate forms for testing and required only to be turned to size. They were unfortunately too short to admit of applying the micrometer screws for measuring the extension with accuracy.

Name.	*Mark.*	*Diameter.*	*First Length*	*Second Length.*
10 per cent. Al Br.	I	·796 inches.	2·43 inches.	2·495 inches.
10 " "	II	·617 "	2·64 "	2·74 "

The breaking loads and tenacities were:

Mark.	*Breaking Load.*	*Tenacity.*
I	27,300 pounds.	55,532
II	14,654 "	48,979

Both of these pieces showed very poor fractures, and seemed to contain free impurities; there were also apparent long crystals, arranged radially about the axis of the pieces. These defects were evidently produced at the same time. From this mishap in their preparation, the tenacities above given are no real criterion by which to judge the properties of the bronze. Several tensile tests were made with thin sheet metal, that showed in one instance a remarkable strength.

These tests were made on an Olsen machine, which, for the small loads required, is more accurate than the large machine already mentioned. The specimens were cut nearly to size, and shaped afterwards, by filing. Fillets were also cut with the file, and the central part of the piece made narrower to avoid a possible break in the chuck.

Mark.	*Length.*	*Breadth.*	*Thickness.*	*Tenacity.*
5 per cent. Al Br.	3·764 inches.	1·472 inches.	·015 inches.	40,846
7½ " "	3·655 "	1·495 "	·015 "	102,567
10 " "	3·795 "	1·483 "	·015 "	51,680

The extension in each case above was about

5 per cent. bronze,	11·2 per cent.
7½ " "	3·0 "
10 " "	4·1 "

These results are a fair average of others that were obtained after the thesis work proper had been completed. The appearance and tenacity of the seven and one-half per cent. specimen indicate that an error was probably made in the original marking, as the tenacity seems without doubt to belong to the ten per cent. bronze. The marks, however, are the same as those furnished the writer.

COMPRESSION TESTS.

These tests were made with specimens cut from original ingot on the planer. The pieces were made of such a size as to first give or yield by buckling, as it is evident that a piece over a few diameters long would thus yield in practice. The tests were made with the compression appliances for the Riehlé machine. An attempt was made to obtain the elastic limit of compression, by use of the micrometer screws, but as the pieces crushed unevenly in each instance, this effort was necessarily futile. The micrometer screws were then removed, and the buckling and actual breaking load observed.

Name.	*Diameter.*	*Buckled at—*	*Broke at—*
10 per cent., Al Br.	·514 inches.	14,500 pounds.	25,000 pounds.
10 " "	·510 "	9,600 "	18,100 "

which gives a resistance to compression of about 125,000 and 88,700 pounds.

The difference in breaking loads is due to the fact that the length of the first was 1·845 inches and the second was 2·0 inches. The final break in each case occurred at the end of the piece, and was such that the final length could not be ascertained. The pieces showed evidence of a considerable "flow" having taken place. This was equally noticeable in the tension and torsion tests.

TORSION TESTS.

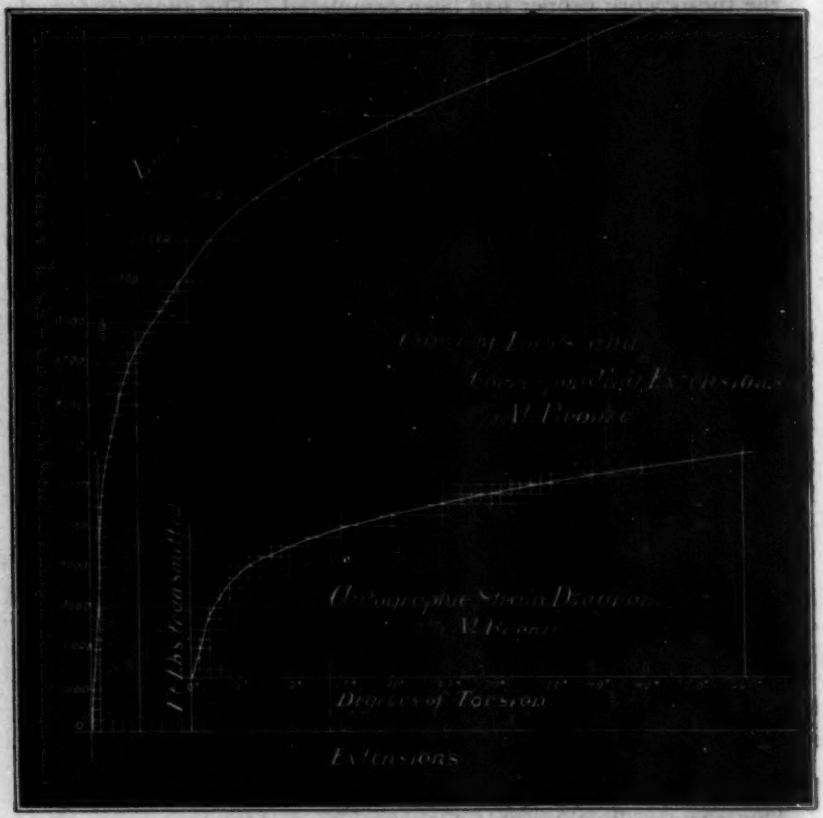
These were made on Thurston's autographic testing machine. The specimens were carefully turned to ⅝ inch diameter and 1 inch long between shoulders. Three pieces were tested, and the results agreed very closely. The following is a mean:

Diameter.	*Degree of Torsion.*	*Elastic Lim.*	*Moment Transmitted.*
·626 inch.	56°·1	4°·1	22·0 foot pounds.

The moment transmitted up to the elastic limit was 9·2 foot

pounds, and the total extension of an exterior fibre was about ·0456.

The strain diagram produced runs up a little higher than that of some wrought irons, but ultimately breaks at less than one-quarter the torsion. The elastic limits of the two metals very



NOTE.—The Curve beyond 13,000 is approximate only. Breaking Load, 23,160 pounds. Tenacity, 65,184 pounds.

nearly agree, and as this is properly the most important consideration, we may say that for resisting torsion, the ten per cent. bronze is substantially as good as wrought iron.

From an inspection of the autographic curve, most of the properties can be discovered that tend to establish the usefulness of the bronze.

ELECTRICAL CONDUCTIVITY.

The electrical resistance of two pieces of Al bronze wire was obtained by the usual methods. The wire was wound in coils and insulated by paper. The heat obtained was from an air-bath. The following are the actual resistances obtained at different temperatures, Centigrade, by three experiments with the same wire. It will be observed that the resistance was variable as the temperature increased, and is doubtless caused by molecular changes until the wire became annealed.

Temp. C.°	*Resist. Ohms.*	*Temp. C.°*	*Resist. Ohms.*	*Temp. C.°*	*Resist.*
32°	1·81	18°	1·79	19°	1·79
34°	1·84	31°	1·80	28°	1·80
47°	1·85	40°	1·80	53°	1·81
53°	1·86	43·5	1·81	63°	1·815
58°	1·87	52°	1·82	67°	1·82
63°	1·88	63°	1·82	78°	1·83
69·5	1·89	72·5	1·83	89°	1·835
76°	1·89	85°	1·84	91°	1·835
79°	1·89	92°	1·845	92°	1·835
80°	1·89	94·5	1·845	93°	1·84
90°	1·89	95°	1·85	95°	1·84
95·5	1·89	96°	1·85	96°	1·85
97·5	1·89	97·7	1·86	96·5	1·855

Weight of above five per cent. wire, ... 3·219 grams.
" " " " " per foot, . . . ·4315 "

The length of wire used was 7·46 feet, which gave a resistance of about ·24 ohms per foot at 65° F.

The piece of ten per cent. wire being short and of large diameter, it was deemed advisable to secure to its ends large pieces of copper wire to be passed to the binding posts, where it was connected. Many attempts were made to unite the copper and bronze wires by solder, but in no case could a firm joint be made. The ends of the copper wires were finally drilled, and the bronze wire was inserted and held by hammering the ends of the copper wires to close the holes tightly on the bronze.

The following table of resistances was obtained on treating the wire similarly to the five per cent.

Temp. C.°	*Resist. Ohms.*	*Temp. C.°*	*Resist. Ohms.*	*Temp. C.°*	*Resist.*
20	·13	22	·13	18·25	·14
25	·13	24	·13	25°	·14
32	·13	43	·14	32°	·14
36	·13	63	·14	50°	·145

Temp. C.°	*Resist. Ohms.*	*Temp. C.°*	*Resist. Ohms.*	*Temp. C.°*	*Resist.*
43	·13	73	·145	59°	·15
53	·13	84	·15	63°	·15
60	·13	88	·15	72°	·15
70	·14	90	·15	79°	·15
77	·14	94	·15	82°	·15
81	·14	95	·15	84°	·15
85	·15	..	..	86°	·15
90	·15	..	..	90°	·15
93	·15	..	..	93°	·15
95	·15	..	..	95°	·15

The length of this wire was 4·36 feet and weighed 7·9582 grams per foot, giving a resistance at ordinary temperatures of about ·03 ohms per foot.

The heat-conductivity of five and ten per cent. bronzes is very high, and not much less than that of copper. The experiments which showed these results were made with pieces of bronze, which, though unsuitable, were the best obtainable at the time. As the work was therefore made under unfortunate conditions, the results obtained probably only express the relations each alloy sustains to copper in conductivity.

The writer is preparing to take up the subject of conductivity of heat with more suitable material and apparatus, and somewhat enlarge the field of investigation. The details of the experiments and methods pursued, can be better explained then than now.

The conductivity of the five per cent. was nearly equal to the copper used, while that of the ten per cent. was slightly less.

FRICTIONAL TESTS.

The frictional or anti-frictional properties of aluminium-bronzes have so long been boasted in various writings, that the results of the following tests, made on Thurston's lubricant tester, may be of interest.

A sleeve of ten per cent. bronze was turned to run accurately in hardened steel boxes, placed in the pendulum of the above machine, and run at 300 pounds pressure and 1,200 revolutions per minute, until the surfaces in contact were worn smooth. During this process, the pendulum was occasionally removed to admit of polishing with crocus cloth, the places that had worn rough. After the journal had thus been run for a day, a similar one of ordinary box metal was treated in the same way. After each was made perfectly smooth, they were carefully cleaned from oil with benzine, cooled and weighed.

The test then made consisted in running each for ninety minutes, and noting the temperature of the journal and deflection of the pendulum every five minutes.

The steel boxes used were cut away on the sides and came in contact with the journal only on the top and bottom. This permitted a greater pressure to be employed and allowed a freer circulation of oil. The oil used was winter bleached sperm, used as a standard for comparing oils sent to the STEVENS INSTITUTE to be tested.

An observation of the following table will show the exact behavior of each alloy tested.

Al Bronze, 10 per cent.			Box Metal.		
Temp. F.°	*Deflec.*	*Time.*	*Temp. F.°*	*Deflec.*	*Time.*
84	1·5	0	75	1·6	0
90	1·4	5	83	1·6	5
94	1·4	10	90	1·5	10
99	1·3	15	95	1·4	15
102	1·3	20	99	1·4	20
108	1·3	25	102	1·3	25
110	1·3	30	104	1·3	30
110	1·3	35	104	1·3	35
110	1·2	40	105	1·3	40
110	1·2	45	105	1·3	45
111	1·2	50	105	1·2	50
111	1·1	55	107	1·2	55
111	1·1	60	109	1·2	60
111	1·1	65	109	1·2	65
111	1·1	70	109	1·2	70
111	1·1	75	109	1·2	75
111	1·1	80	109	1·2	80
111	1·1	85	109	1·2	85
111	1·1	90	109	1·2	90

Weight of bronze before test,	148·918 mgs.	Weight of box metal before test,	166·3675 mgs.
Weight after,	148·890 "	Weight after,	166·3635 "
Difference,	·028 "	Difference,	·004 "

From these data, it is noticed that with the bronze journal, the friction is less and the temperature of the journal higher; but the wear is very great compared with box metal.

The loss of weight is probably greater than if a steel journal were used to run in aluminium-bronze boxes.

The wearing capacity of the bronze doubtless depends on a

very slight change of some of its ingredients, or the addition of some hardening element. If the excessive wear can be prevented without, at the same time, increasing the friction or temperature of running, aluminium-bronze can be made a formidable competitor with the various box metals in the market.

The following analysis of ten per cent. bronze was made in the chemical laboratory of STEVENS INSTITUTE.

Carbon,	1·5 per cent.	1·3 per cent.
Silicon,	6·4 "	6·5 "
Copper,	87·5 "	88· "
Aluminium,	5·2 "	6·3 "
	100·5	102·1

The writer is indebted to Messrs. H. Y. Castner, Douglas Dixon, and others for suggestions and information useful in the preparation of the foregoing pages. He especially desires to acknowledge the kindness of the Cowles Electric Smelting and Aluminium Company, which furnished not only valuable information, but many specimens of their products for the purposes of this investigation.

THE STEREOSCOPE AND ITS APPLICATIONS.

BY PROF. CHARLES F. HIMES, Ph.D.

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *January 14, 1887.*]

At the Eighth Meeting of the British Association for the Advancement of Science, August, 1838, a paper was read by Prof. Charles Wheatstone, accompanied by an instrument illustrative of it, which involved in so high a degree the elements of novelty and great intrinsic scientific value, that it was received with most decided manifestations of pleasure and surprise. The subject of the paper was, "Binocular Vision, and an Instrument for Illustrating its Phenomena," which latter was called by him a stereoscope. The reception accorded the paper and the instrument, and the importance attached to it, can be most briefly placed before you, by an abstract from the proceedings of that body, which I will read from the *American Journal of Science* (**35**, No. 2, p. 295), giving the opinions of two representative men, as follows: "Sir David Brewster feared that the members could scarcely judge

from the very brief and modest account given by Prof. Wheatstone, of the principle and of the instrument devised for illustrating it, of its extreme beauty and generality. He considered it one of the most valuable optical papers which had been presented to the Section. He observed that when taken in connection with the law of visible direction in monocular vision, it explains all those phenomena of vision by which philosophers have been so long perplexed, and that vision, in three dimensions, received the most complete explanation from Prof. Wheatstone's researches. Sir John Herschel characterized Prof. Wheatstone's discovery as one of the most curious and beautiful, for its simplicity, in the entire range of experimental optics."

Now, although the instrument, as is apparent, could not but be of great general interest outside of purely scientific circles, its application seemed so hedged about with limitations, that it hardly promised to become a popular instrument. But about the same time, Daguerre made the announcement of his great discovery, which not only widened the field of application of the stereoscope, by bringing within its range many subjects previously hopelessly excluded, but in its subsequent development so completely supplemented Wheatstone's discovery, by its cheap multiplication of pictures of all objects, of mathematical accuracy, that the stereoscope became the scientific sensation of the day, and found its way into the parlor as well as the study. It seemed to have acquired for itself a permanent place in almost every intelligent household.

Now, in the treatment of this subject this evening, it seems that the best disposition of the time at our disposal can be made by considering, first, rather hurriedly, the principles underlying and explanatory of the instrument, and then as many of the most characteristic applications as the time may allow, with incidental discussion of theoretical considerations and disputed points, as they may present themselves. Just at this point, I desire also to state that as many statements in the nature of the case are not susceptible of confirmation or illustration, by means of flat drawings, reproduced upon the screen, a number of stereoscopic illustrations will be open to examination, with the aid of the instruments, at the close of the lecture, to such as may desire.

I have given Prof. Wheatstone's paper the prominence I have,

because the whole subject seems to develop most naturally by inquiry into his merits in this connection. What, then, was his discovery? What is his claim? I think I can safely say that it is broader than the simple invention of the instrument, which he called a stereoscope. It was the conception which preceded the instrument, which suggested it, which, in fact, demanded it, and called it into existence, that had the prime element of novelty in it. This statement may almost seem superfluous, but I make it here at the outset, because Sir David Brewster, apparently forgetful of the generous tribute to Prof. Wheatstone, which I was careful to read a few moments ago, subsequently made labored efforts to restrict the claim of Prof. Wheatstone to the invention of an instrument, and that an instrument which, as he at the same time contended, is inferior to the lenticular stereoscope of his own invention, now in popular use. What, then, in brief, was the state of knowledge and the theory of vision at that time? The physical explanation of vision by the formation of a distinct image of external objects upon the retina of the eye was entirely satisfactory. The eye, optically considered, was regarded as a camera obscura, with the retina as the ground-glass. This instrument has become so common to-day, by the rapid spread of amateur photography, that familiarity with it may be assumed without further explanation. There were, to be sure, some remaining difficulties to be explained away, but they were often manufactured, and rather physiological or psychological in character. The notable one, how inverted retinal pictures can occasion erect vision of objects—is closely related to our subject by the *law of visible direction*, alluded to by Sir David Brewster, which explains it. A law which, simply stated, is that visible points are referred back to positions in lines along which the light from them finally strikes the retina, or that we see points in the direction in which light from them strikes the retina. But the consideration of vision with two eyes introduced new complications, and perplexing questions peculiarly its own. Having two eyes, each evidently receiving its own retinal picture, we nevertheless receive but a single impression, or we see the object single. How, where, when do these two impressions fuse into one? But on further consideration, the difficulty is intensified. The retinal pictures in the two eyes are not identical, but in the nature of the case must be essentially

different—as different as the drawings of an object made from two different points of view, as distant from each other as the interocular distance. It is certain, then, that our clear, unconfused single mental impression exists in spite of the dissimilarity of the retinal pictures of the two eyes. But upon still further investigation, it is found, that not only does no confusion result from these separate dissimilar pictures presented to the mind, as it were, at the same time, but, what is still more remarkable, that from these dissimilar retinal impressions, and by reason of their dissimilarity, no doubt, we have more definite perception of external objects. In whatever way explained, the fact was indisputable that there results from this dissimilarity of retinal impressions such a perception of distance and, consequently, of form, that it seems, as some contend, an added direct perception of distance, and not the result of an unconscious judgment, based upon additional data furnished by the two eyes. There can be no physical explanation of this seeming fusion of dissimilar retinal impressions, and the resulting additional perception. It must be clearly physiological or psychological, or both. But although assent is generally readily given to the fact just stated, its importance in this connection is such that it may be allowable to emphasize it by testing it by an experiment, something, too, in the nature of a quantitative experiment. Any two persons will answer the purpose. (Two gentlemen presented themselves, and were furnished with lead pencils.) Now, if you please, take a position opposite each other, about an arm's length apart. Let the gentleman on the left hold his pencil in a vertical position, about half an arm's length from his body, and the gentleman on the right hold his similarly, but with its lower end several inches higher than the upper end of the other pencil; and now, with one eye closed and the head held in a fixed position, let him move his hand forward until the point of his pencil seems to be directly above that of the other pencil, and now bring it down upon it. The result shows how erroneous the estimate; with both eyes open, there is no difficulty in bringing them together. Repeat the experiment as often as you please, the only variation will be an accidental one in the magnitude of the error. I held this newspaper screen up between the parties during the experiment, so that no other criteria of distance might accidentally be introduced, more particularly the movement of the arm.

because the whole subject seems to develop most naturally by inquiry into his merits in this connection. What, then, was his discovery? What is his claim? I think I can safely say that it is broader than the simple invention of the instrument, which he called a stereoscope. It was the conception which preceded the instrument, which suggested it, which, in fact, demanded it, and called it into existence, that had the prime element of novelty in it. This statement may almost seem superfluous, but I make it here at the outset, because Sir David Brewster, apparently forgetful of the generous tribute to Prof. Wheatstone, which I was careful to read a few moments ago, subsequently made labored efforts to restrict the claim of Prof. Wheatstone to the invention of an instrument, and that an instrument which, as he at the same time contended, is inferior to the lenticular stereoscope of his own invention, now in popular use. What, then, in brief, was the state of knowledge and the theory of vision at that time? The physical explanation of vision by the formation of a distinct image of external objects upon the retina of the eye was entirely satisfactory. The eye, optically considered, was regarded as a camera obscura, with the retina as the ground-glass. This instrument has become so common to-day, by the rapid spread of amateur photography, that familiarity with it may be assumed without further explanation. There were, to be sure, some remaining difficulties to be explained away, but they were often manufactured, and rather physiological or psychological in character. The notable one, how inverted retinal pictures can occasion erect vision of objects—is closely related to our subject by the *law of visible direction*, alluded to by Sir David Brewster, which explains it. A law which, simply stated, is that visible points are referred back to positions in lines along which the light from them finally strikes the retina, or that we see points in the direction in which light from them strikes the retina. But the consideration of vision with two eyes introduced new complications, and perplexing questions peculiarly its own. Having two eyes, each evidently receiving its own retinal picture, we nevertheless receive but a single impression, or we see the object single. How, where, when do these two impressions fuse into one? But on further consideration, the difficulty is intensified. The retinal pictures in the two eyes are not identical, but in the nature of the case must be essentially

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We cannot with one eye open, with certainty, bring the tips of the index fingers together at arm's length, or snuff a candle. Indeed, we often find ourselves almost with a feeling of a loss of clear vision when we are obliged to estimate distance without being able to bring both eyes to bear upon the same point. It is clear now, I think, that no picture of an object, however accurate in drawing, or faultless in all respects, can produce the same infallible impression as that produced by the object itself, which furnishes us, through the two eyes, two dissimilar pictures of the object. All the criteria of distance and form that can be introduced into a drawing are, in the nature of the case, monocular. They may be manipulated and reinforced, but not changed in character, and by none of them, nor by all of them together, nor by any treatment of them can an infallible judgment as to form be reached.

FIG. 1.

Our judgment in such cases is controlled, to a great degree, by conditions and facts external to the drawing. This is another of those statements readily acceded to, but hardly accorded its full practical importance, especially in this connection. To impress it more decidedly, I will bring before you a few illustrations, which also have an additional interest of their own. In his treatise on the Stereoscope,* Sir David Brewster devotes considerable space to what he styles "a very remarkable illusion," a "puzzling phenomenon," to which his attention was first called by Prof. Neckar, of Geneva. The diagram (*Fig. 1*), now on the screen, he remarks, was so drawn that *A* should appear nearest the spectator, and the face *A B C D* foremost, and *x* farthest from him. But he says, on

* *The Stereoscope*, p. 228.

looking at it repeatedly, the apparent position of the rhomboid is changed, x and its face will appear in front, and A and its face will appear more remote, and give the solid a different inclination. Any of you can readily test these statements by means of the diagram on the screen. You can cause A or x to come to the front, or to recede at will. Now this results from the simple fact that the two solids are represented by the drawing. Sir David says it was drawn so that A should appear in front. That may be so; but there is nothing in the drawing to justify the statement. Had the artist intended x to appear in front, he would have drawn precisely the same figure. In reviewing this book some years ago, this puzzle recalled some early ones of my own, and I suppose of almost any boy, entering upon solid geometry. But doubtless you all see first the solid with A in front. This I would explain by the fact, that that solid appears in a natural position, fully supported; whilst the

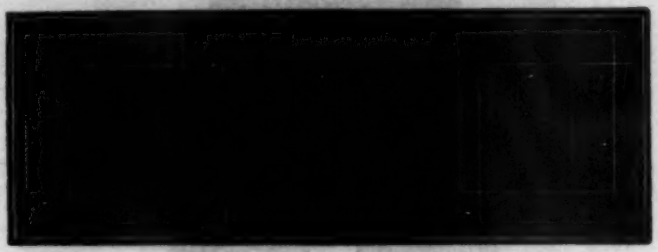

FIG. 2.

other solid, represented when x is in front, is in an unnatural, unsupported, I would almost say, impossible position. That solid that has the most usual position, is first suggested, and I have no doubt that this particular diagram arrested the attention of Prof. Neckar, and afterward of Sir David Brewster, simply because of the accident, that it represents two solids differing so widely in this respect. I have simplified this in the diagram now on the screen, (*Fig. 2*), to which I will call attention again in another connection. In either of the diagrams it will require very little effort to cause either of the squares to appear in front of the other. There is no reason, in the nature of the case, why one should appear in front rather than the other. There is another diagram illustrative of this point frequently referred to as Schroeder's* steps, (*Fig. 3*), that

* *Poggendorff's Annalen*, **105**, 298. Helmholtz, *Handbuch der Physiologischen Optik*, p. 626.

it will be presented for an instant. At first glance, the outline and the shaded drawings, doubtless to every one represent steps in their most natural position, but by a very little effort they can be converted into overhanging steps.

But it might be said that a monocular picture of the *object itself* upon the retina of a single eye, should also be capable of this two-fold interpretation. That in looking at an object with one eye, we should receive no infallible impression as to its form. Neither do we. But in most cases the prepossession given by other circumstances renders it impossible to recognize other than one. But if an object is taken, in which this difference in naturalness or usualness, so to speak, of the two objects represented is reduced to a

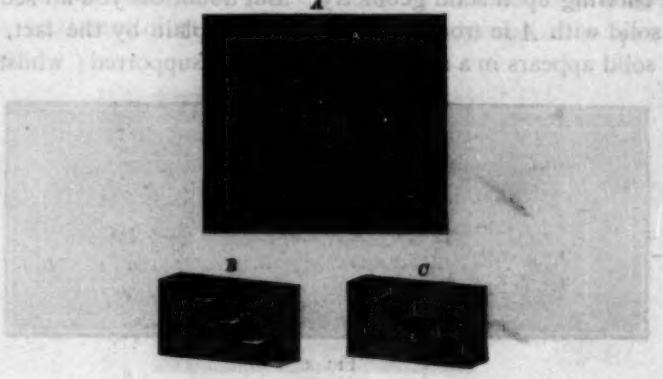

FIG. 3.

minimum, we will find how readily we can be deceived. The photograph upon the screen seems to represent a medallion in relief. I do not hesitate to assert, that no one is able to imagine it to be anything else, and yet it is a photograph of a mould I hold in my hand. What is true of the photograph is equally true of the retinal impression formed by the object on one eye. When looked at with one eye, with the head immovably fixed at the distance of several feet, it will invariably and persistently appear as a relief, and I think simply because objects of the kind are far more frequently met with in relief than as intaglios, and we cannot emancipate ourselves from the effect of this circumstance. Both eyes, however, soon settle the true character of the object. It is possible that one accustomed to work in plaster, as familiar with

moulds as the casts made from them, could see it as readily as a mould as a cast.

It may be admitted that this superiority of binocular over monocular vision, and the essential conditions of it were recog nized before Prof. Wheatstone's paper was read, but he seems to have been so impressed with these facts, that it occurred to him, as there is no reason to believe it occurred to any one before him, that, if he could, by any means, reproduce the conditions of binocular vision by means of flat drawings, he could also produce the irresistible impression of solidity of form; that is, if he could, by any means, simultaneously produce in the two eyes retinal impressions of such a degree of dissimilarity as an object would produce when looked at with both eyes, a perfect binocular illusion of the object would be produced. If, for example, he could present

FIG. 4.

to the left eye the picture of the frustum of a cone as seen by that eye, and at the same time the picture of the same frustum to the right eye, as seen by that eye, as in the diagram (*Fig. 4*), the same effect of perception of complete relief should be produced as by the presentation of the object itself. But he did more; he demonstrated experimentally and conclusively the correctness of his reasoning. But an apparently insurmountable difficulty is encountered in any attempt to look at the same time at one picture with one eye and at another with the other eye. It lies in the fact that as we see but one point of an object with greatest distinctness at a time, we direct both eyes invariably to the same point, and thus in passing from point to point roll the eyes inward, if to a nearer point, outward, if to a more remote point. In other words, we direct the optic axes to that point, and cause its image to occupy the place of

most distinct vision in each retina. At the same time, we accommodate the eye—adjust it focally to distinct vision of this point.

It is this play of the optic axes, this variation in the angle formed by them, or, if you please, the muscular effort required to produce it, in turning from one point of an object to another, that, in some way, seems inseparably connected with our infallible binocular perception of distance. Whether by reason of it, this perception is original, antecedent to experience, according to the so-called *nativistic theory*, or whether it is dependent upon it simply as upon a peculiar criterion of judgment, and is wholly the result of experience, according to the *empiristic theory*, has been a matter of great dispute. No one has more clearly enunciated the latter theory than Bishop Berkley, whilst on the other hand Sir David Brewster has as warmly disputed it. Now, although closer investigation forces to the conclusion, that simple play of optic axes will not wholly account for binocular perception of distance, yet the great preponderance of opinion is in favor of the view that this perception of distance is not primary, but is an unconscious visual judgment. It would hardly repay to give much time to the discussion of this point. I will simply call attention to a fact, that seemed almost conclusive to me upon investigation of it some years ago.*

New-born infants not only have no perception of distance, but seem to have no tendency to move their eyes in concert. As a rule, they appear cross-eyed, without, however, a decided in-squint or out-squint, but rather with a peculiar working of the eyes, resulting from want of concert in their movements. This vanishes after a short time, and the unvarying habit of convergency accompanies the acquisition of perception of distance.†

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* *American Journal of Photography*. Vol. v, p. 114. (1862.)

† Any argument against this view from the analogy of the lower animals must be received with great caution. Many of the lower animals possess only monocular vision on account of the position of the eyes, which precludes concerted use. The absence, too, in almost all lower animals of a retinal area of most distinct vision removes the incitement to concerted action of the eyes. The argument from the young of birds, by Adam Smith, seems to have more weight conceded to it by Sir William Hamilton than it merits, especially when it is remembered that most birds, other than the carnivorous, have their eyes so situated that they cannot be used in concert. They may be often observed to turn the head and look steadily with one eye at an object, making a purely monocular study of it.

Now, when we look at a stereograph in ordinary vision, both eyes look at the right-eye picture, or left-eye picture, at the same time; the axes intersect in a point in the plane of the paper, and, at the same time, both eyes are accommodated to the plane of the paper, so that when we require the right eye to look at its half of the stereograph, and the left eye to look at its half, at the same time, we call for a violation of this consensual habit of convergence of the axes and accommodation of the eyes to the same point. For, whilst the eyes would be accommodated for distinct vision to the plane of the paper, the point of intersection of the axes would be more remote, if indeed, as we shall see after awhile, they intersect at all. But, whilst this dissociation of invariably associated optical adjustments is difficult, it can be accomplished by any one

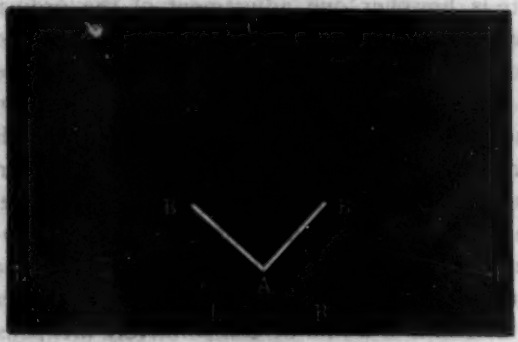

FIG. 5.

with some effort and some patience, and when, upon looking at a stereograph, the effort is successful, the picture springs out into inimitable, almost magical, relief, as we have reason to believe first happened to Wheatstone.

But Wheatstone devised an instrument to aid in presenting the dissimilar pictures to their respective eyes at same time without this violation of habit. Optically it is extremely simple in principle. In the diagram, (*Fig. 5*) L' and R' are similar points in the left-eye and right-eye pictures, L and R, the left and right eye, and $A\,B$ and $A\,B'$ plane mirrors. The rays of light from R' will enter the right eye as if proceeding from C, and those from the similar point L' enter the left eye, as if from the same point C, and accommodation and convergence of the axes will be to the same

point, when these similar points of the two pictures are looked at. As it is generally stated, the instrument superposes the two pictures. Now, there are many instruments by which this superposition, so to speak, may be accomplished. Refraction suggested itself to Sir David Brewster instead of reflection as employed by Wheatstone. He devised the form of stereoscope now in general use, which the word suggests to most persons, in which lenticular prisms replace the mirrors, thus affording not only a more compact and convenient instrument, but one that permits both pictures to be mounted upon the same card as in the ordinary stereograph. There are many other stereoscopes, in great variety, all interesting, many of them curious, but as a rule they only serve to demonstrate that the same effect of superposition can be produced in still another way. There is, however, one adjustment of the ordinary stereoscope, of very decided value, but which is invariably wanting. It is an adjustment of the lenses to the variable distance between the eyes of different individuals, and at the same time to the slight variation in distance of similar points in stereographs in the market, or, if they are properly mounted, we might say to their breadth. Much of the dissatisfaction and want of comfort in the use of a stereoscope in many cases is due almost exclusively to this want of adjustment to the interocular distance of the individual, accomplished by sliding the prisms nearer to or further from each other. Although this addition would be comparatively inexpensive, there seems to be so little popular demand for anything beyond the simplest and cheapest forms, that they are not kept in the market even after advertised. One recently devised by Prof. Le Conte Stevens,* having this adjustment, and many others valuable in its employment for investigation, I regret to say, cannot be obtained from a leading firm which has largely advertised it.

(*To be continued.*)

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* *American Journal of Science*, March–April, 1882.

A NEW METHOD TO DETERMINE THE MOON'S MASS CORRECTLY, FOLLOWED BY A DISCUSSION UPON THE THEORY OF TIDES FULLY IDENTIFYING THE PHENOMENON UPON DYNAMICAL PRINCIPLES.

BY L. D'AURIA.

(*Continued from Vol. cxxiii, page 334.*)

[*Presented in a Lecture delivered before the* FRANKLIN INSTITUTE, *Friday, February 25, 1887.*]

The definition already given of the values of D and ω in equation (1), is not sufficient when we consider that even in quadratures the mass M may be found under the influence of an accelerating force in the direction μM, and which should be taken into account in the first of our fundamental equations. But remembering that such force must be zero at the time when M has acquired its maximum velocity in that direction, and that this takes place when M is at right angles, or nearly at right angles, to the line of apsides, our fundamental equations remain the same, provided the values of D and ω are taken in quadratures occurring with the sun on that line. Therefore, equation (1) can be used for these particular values of D and ω only, and no others, and which cannot be observed but twice every nine years, owing to the motion of the lunar apsides.

Let D_m, ω_m represent the values of D and ω, taken when M is at right angle to the line of apsides; α, the inclination of this line with respect to the sun; ω_1, the angular velocity of the earth and moon around the sun; then the sun's disturbing force upon M in the line μM will be found very approximately expressed by $3 M \omega_1^2 x \sin^2 \alpha$. In fact, if we denote by a, the sun's distance from the common centre of gravity of the earth and moon, and by S, the sun's mass; then, while M is at right angle to the line of apsides, its distance from the sun will be $(a + x \sin \alpha)$; and its centrifugal force around the sun will be $M \omega_1^2 (a + x \sin \alpha)$. The sun's attraction upon M will be—

$$\frac{\sigma S M}{(a + x \sin \alpha)^2};$$

and observing that $\sigma S = a^3 \omega_1^2$, the sun's disturbing force upon M will be—

$$M \omega_1^2 (a + x \sin \alpha) - \frac{M a^3 \omega_1^2}{(a + x \sin \alpha)^2},$$

or,

$$M\omega_1^2 \frac{3a^2x\sin a + 3ax^2\sin^2 a + x^3\sin^3 a}{(a + x\sin a)^2}.$$

Since x is very small with reference to a, this expression can be reduced to $3M\omega_1^2 x\sin a$; and its projection upon the line $M\mu$, which represents the sun's disturbing force in that line, will be $3M\omega_1^2 x\sin^2 a$.

Now we have the following equations for the determination of the moon's mass; viz.:

$$\frac{cM\mu}{D_m^2} = M\omega_m^2 x + 3M\omega_1^2 x\sin^2 a; \quad Mx = \mu(D_m - x);$$

which offer—

$$\frac{M}{\mu} = \frac{\rho^2 g}{D_m^3(\omega_m^2 + 3\omega_1^2\sin^2 a) - \rho^2 g} \tag{3}$$

If we designate by D_{mq}, ω_{mq}, the values which D_m, ω_m, assume in quadratures; that is, when $a = 0$, we have

$$\frac{M}{\mu} = \frac{\rho^2 g}{D_{mq}^3\omega_{mq}^2 - \rho^2 g} \tag{4}$$

which in the limitations already assigned to D and ω in equation (1), are identified.

Comparing equations (3) and (4), we get the remarkable relation—

$$D_{mq}^3\omega_{mq}^2 = D_m^3(\omega_m^2 + 3\omega_1^2\sin^2 a) = \text{const}; \tag{5}$$

from which can readily be concluded that the term $D_m^3\omega_m^2$ in quadratures becomes a maximum. Hence, if D and ω are mean values, we have, most likely,

$$D^3\omega^2 < D_{mq}^3\omega_{mq}^2,$$

which would account for the rather deficient value of the moon's mass found in our foregoing computations. However, not until the constant (5) has been properly determined, we can by any means pronounce the last word about the value of the moon's mass; and it is to be hoped that astronomers, in the interest of their science, will soon arrange for a series of concerted observations to accomplish this result.

With this, the first part of our paper is concluded, and we shall now enter upon the theory of tides.

(To be continued.)

BOOK NOTICES.

THE LIFE AND WORK OF THOMAS GRAHAM, D.C.L., F.R.S. Illustrated by sixty-four unpublished letters, prepared for the Graham Lecture Committee of the Glasgow Philosophical Society, by Dr. R. Angus Smith, LL.D., F.R.S. Edited by J. J. Coleman, F.I.C., F.C.S. Published by John Smith & Son, West George Street, Glasgow. 1884.

In 1878, some leading manufacturing chemists of Glasgow subscribed a sum, which was put at the disposition of the Chemical Section of the Philosophical Society of Glasgow, for the encouragement of original research. They associated this idea with the name of the most distinguished Glasgow chemist of whom they could think, and that was Thomas Graham. Dr. R. Angus Smith was invited to deliver a lecture on the life and activity of Graham, and he agreed to do so, making the basis of his sketch from letters, in his possession, of Graham to his relatives and friends, from his first year of emancipation from the duties of a scholar, about 1826, to a letter to Miss Graham Pau, of February 11, 1863. In these letters there is much that interests the general public, chiefly from the fact that it proves how human even great men are.

It would be strange if this should need further confirmation, or if the confirmation should elicit interest, but it is so. His sister Margaret and his mother have the lion's share of the letters. Side lights like the following, on other great men, strike their worshippers unpleasantly. "Edinburgh, July 7, 1826. Sir Walter '[Scott]' must have been a calculating genius. It turns out that he was almost sole proprietor in the printing establishment of Jas. Ballantyne & Co., who have failed, so that he intended not only to profit by writing the novels, but also to have a good share in the profits of printing them. Ballantyne was little more than his servant," etc. Quite droll is the following:

"EDINBURGH, October 15, 1826.

"*My dear Mother:*

"My operations have been interrupted for two or three days. I find a room which Miss Cameron occupies at night as a sleeping-room, and which is otherwise unoccupied, forms a very good laboratory for the experiments in which I am engaged, and likely to be engaged for a considerable time. They are doing very well—"

At this period commenced the anguish at the accidents which prevented his articles from being printed in the *Quarterly Journal of Science*, and the *Annals;* the gratification at a perfunctory politeness or two; the satisfaction at being temporarily installed as "Prime Minister" of Chalmer's *Miscellany*, etc.

It is hard to realize that such things made the same impressions on men of Graham's mould as on lesser clay. He wishes to go to London. All Britons do.

Following the letters is a short biographical sketch by Dr. Smith, in which we find that Graham early got into a "very languid mode of life. * * *

He was often in great straits for want of money. Once he required a silver crucible to make some experiments for a commercial firm, but he could not buy one, and *he was refused credit (!)*" etc.

The biography, which succeeds this short sketch, is very ill-arranged, and skips about among subjects and dates in a confusing manner.

The appendix, or "critical remarks," to the foregoing pages of Thomas Graham, being a preface by Dr. Angus Smith to *Physical Researches of Thos. Graham*, published for private circulation by Dr. R. Angus Smith and James Young, in 1876, is one of the best treatises extant on the general subject of atoms, and the extent to which the ancients (and to some extent the "intervening thinkers") anticipated modern views. P. F.

THE NEW SOUTH. A Description of the Southern States, noting each State separately, etc. By M. B. Hillyard. *Manufacturers' Record* Company, Baltimore, Md. 1887.

This is an "offering of love to the South," well deserved and ably executed, in an 8vo volume of nearly 500 pages, wherein her wonderful progress in agriculture, arts and sciences, during the past fifteen years especially, is shown and supported by convincing data. We regret that it is impossible here to give proper extracts from the last, but a partial *résumé* will aid in affording a fair idea of the changed condition and the great advance. In all the Southern States, introduction of free labor, more diversified production, and use of improved agricultural machines from the Northwest and North, have largely contributed to the following change, in eighteen years, in agricultural production:

	Bushels.		
	Corn.	*Wheat.*	*Oats.*
1885,	470,776,000	53,526,000	78,675,000
1968,	354,124,000	31,822,000	32,583,000
Increase,	116,652,000	21,704,000	46,092,000

The total amount of coal mined in nine Southern States in 1870, was 3,193,190 tons, and in 1885 it had advanced to 12,511,539 tons. The increase here noted in the utilization of cotton-seed in eleven States, is for seven years only, viz.:

	Capital.
At the close of 1880, there were 40 mills,	$3,504,500
" " 1885, " 146 "	10,792,450

The number of pounds of cotton raised in 1886 was nearly double the quantity of 1870; and in nothing, perhaps, has the South advanced so much as in its manufacture of cotton. In January, 1887, the number of cotton mills in thirteen Southern States was 353, as against 180 in 1880, being a gain of 173 mills. North and South Carolina, Georgia and Tennessee are the States showing most increase in this respect, during the past seven years, viz.:

	1880. Per U. S. Census.		*1886.*	
	Looms.	*Spindles.*	*Looms.*	*Spindles.*
Georgia,	4,713	200,974	8,648	385,613
North Carolina,	1,960	102,767	3,118	257,576
South Carolina,	1,776	92,788	4,579	224,732
Tennessee,	1,068	46,868	1,528	117,444

In 1880, the South had but 6·7 per cent. of the 10,635,435 cotton spindles in operation in the United States, but now the proportion is nearly eleven per cent.

The increase in production of iron is one of the most surprising of all; the world has never shown a similar record of progress, for six years, in any mineral department.

	1880.	*1881.*	*1882.*	*1883.*	*1884.*	*1885.*
Alabama, tons of iron,	77,190	98,081	112,765	172,465	189,664	227,438
Virginia, " "	29,934	83,711	87,731	132,907	157,483	163,782
Tennessee, " "	70,873	87,406	137,602	133,963	134,597	161,199
Total,	177,997	269,198	338,098	459,335	487,744	553,419

Alabama, with Birmingham as chief centre of production, is becoming one of the greatest iron producers of the world; and one of its principal advantages is the cheapness of production. It is stated that, at Birmingham, $8 per ton covers all expenses, and Bessemer steel can be made there for $10.50 per ton.

Passing over much that might be shown of improvement in other industries such as saw, planing and sash mills, silk, hemp, etc., and the existence of vast mineral deposits, including phosphates and marls, as yet only slightly developed, the increase in mileage of railroads, an immense amount of water-power running to waste, and large tracts of virgin forest still standing in many portions—we close this imperfect summary by some remarks from the last part of the introduction of this interesting book:

"To the writer, no aspect of Southern progress is so marked and cheering as the hopeful, erect, self-assertive, industrial spirit of the South. * * * Time was when she had almost no courage to undertake manufacturing. The few cotton mills could not sell their goods to the Southern trade direct, but had to send them to Northern salesmen, who sold them to the merchants within the shadow of the mill where they were made. The South thought her manufactures were next to worthless. She must needs have New England goods. But this has passed away now; she believes in her capacity to do. It is not the rash and presumptuous confidence of unreflecting imbecility or inexperienced immaturity; it is a courage based on results. * * * Her aggressive and experimental spirit will carry her into new fields of endeavor, where there are many opportunities for conquest." N.

LUFTDRUCKBREMSE, SYSTEM CARPENTER. 1884. By J. Fairfield Carpenter, Berlin.

This book contains a full description of the Carpenter air brake for railway trains, which is, perhaps, the most formidable competitor to the Westinghouse air brake, so well known in this country.

The adoption of this system, after a lengthy competitive test, upon the railroads operated by the Prussian Government, is regarded by the inventor as an endorsement of the claim of superiority over other systems.

The various modes of application to engines and cars, as well as the details, are presented by eleven well-executed plates, accompanied by detailed description. H. B.

SCIENTIFIC NOTES AND COMMENTS.

PHYSICS.

AN OPTICAL ILLUSION.—A number of years ago, I observed the following illusion. When the eye watches for some time, in complete darkness, a motionless object of small diameter, and feebly lighted, it very often happens that this object appears clearly to move with a certain rapidity in a specific direction. This phenomenon, when it takes place, is very striking, and almost all upon whom I have tried to reproduce it have verified it. It is an appearance analogous to that of a shooting-star, but less rapid. The angular rapidity of the apparent displacement of this object has appeared to me to be between 2° and 3° per second. The direction of displacement is variable. The object appears oftenest to progress in a curved line upwards or outwards, but this direction may be quite different from either. Sometimes the object follows successively different courses; it may describe curves or zigzags. The total extent of the displacement varies; it may attain and exceed 30°. In reflecting upon the possibilities of this illusion, I have thought at first of an unconscious movement of the eye. This explanation must be rejected: the eye remains fixed as well as the object. Indeed, the form of a group of little points very near together may be given to the object, and these cannot be seen except by the centre of the retina. Now, under these conditions the illusion persists; besides, the experiment succeeds with both eyes, and a simultaneous displacement, exactly symmetrical and quite extensive, of the two eyes would not pass unperceived. The illusion, then, does take place when an eye at rest looks fixedly at an object at rest. I have studied, moreover, to see whether the point of departure was not a special position of the eye in relation to the head, which would produce an abnormal, tonic contraction of the muscle corresponding to the apparent sense of displacement of the object; but the different positions I have given to the eye have not prevented the phenomenon from appearing, and have not introduced anything special into it. A fact which may throw some light on the production of this illusion, is that it is possible to provoke a voluntary, apparent displacement of the object in a given direction. It suffices for this, to think of seeing another object, or of accomplishing an act in the desired direction. For example, with my eye at the eye-piece of the dark chamber, which serves me for these experiments, I think of picking up a pin or book on the floor, and I see the object not always, but generally, move down: if I think of the chimney, on the roof which faces my window, the object rises, etc. I repeat it, and there comes a distinct sensation which everybody can obtain. It has been objected that my eye accomplished the supposed movement itself, but this is incorrect; I have assured myself of the contrary. Moreover, it is easy to see that, as the eye looked up, the object must, on the contrary, appear to descend, and vice-versa. Under what conditions do we ordinarily feel that an object moves when the body and head are immovable and we have no

observation mark in the field of vision? (1.) If the eye is at rest, the image of the object moves on the retina, and brings in play a tendency of the eye to move to follow the object. (2.) The image of the object may remain fixed in the middle of the retina, but then the eye moves really to test this fixity, and we perceive this movement of the eye. Now, in our experiment we have indeed this condition, fixity of the retina, but the muscular contraction is missing. Since we perceive really a displacement of the object when we think of a displacement of the eye, it follows then that the idea, as has been said, must be a beginning, a precursor of the motor act, a motor effort not followed by effect. The illusion may then be explained, when it is not provoked by the observer, by unconscious efforts producing themselves in the brain in a manner similar to the association of ideas. In giving this explanation, I wish it understood as a simple hypothesis.—*Comptes Rendus, May 24, 1886.* C.

CHEMISTRY.

BLEACHING ALUMINA COMPOUNDS. *Dingler's Polyt. Journal*, **263**, 164.)—Wilson's "bleaching fluid" is prepared by mixing clear solutions of sulphate of alumina and chlorinated lime—sulphate of lime is precipitated and aluminium hypochlorite remains in solution together with aluminium chloride. R. Weiss (German patent, No. 38,084, April 30, 1886) prepares alumina compounds of stronger bleaching power by causing chlorine gas to react upon aluminates, especially those of sodium, calcium and magnesium. The compounds can be obtained in liquid as well as in solid condition. In the first case, chlorine is passed into a sultably diluted solution of sodium aluminate, or into water in which calcium or magnesium aluminate is floated. In the latter case, chlorine is absorbed by layers of the dry aluminates, and the bleaching compound is obtained in a powder similar to chlorinated lime. It is claimed for these chlorinated alumina compounds, that they act within an extraordinary short time by yielding ozonized oxygen upon mere exposure, without subsequent acid-treatment, and that the fibre is much less corroded than by ordinary "bleach." O. L.

ON A GRAVIMETRIC METHOD OF ESTIMATING TANNINS. H. R. Procter (*Jour. Soc. Chem. Ind.*, **6**, 21)—The author finds the "tan tester" of Müntz and Ramspacher, which, in various modifications, consists of a small filter press, by means of which the liquid to be tested is forced through a piece of wet rawhide, to have failed in practice, the variations by different investigators having been as high as thirty per cent.

It occurred to him that a modification of the process of Messrs. Simand and Weiss (*Dingl. Polyt. Jour.*, **260**, 564,) would approach perfection. An argand lamp-chimney has a perforated cork, covered with muslin, put in its small end and pushed down until it rests on the shoulder near the base; hide powder is then filled in until it occupies a space of about 50 c. c.; another perforated cork, covered with muslin, is pressed down on the powder. The chimney is cut off even with this second cork, and a small tube fitted into the perforation. The wide end of the tube is now dipped into distilled water

until the powder becomes moistened, when the chimney is removed, reversed and fastened in a convenient place. The apparatus now has the appearance of a small percolator, the wide end of the chimney serving the purpose of a reservoir. A strong solution of tannin is now poured in, and allowed to slowly percolate through the powder, leaving its tannin in combination. The object in dipping the larger end into distilled water first, is to moisten the powder, so that the tannin liquor, in its passage, is evenly distributed through the powder, instead of forming channels and running through uncombined. Definite volumes of the liquid are evaporated before and after passing through the hide powder, the difference giving the amount of tannin.

The most serious objection to this process is that gallic acid is likewise absorbed by the hide powder, a one per cent. solution losing seventy-eight per cent. of the total. This condemns the method for rigid scientific work when gallic acid is present, but the author hopes to overcome this difficulty by removing the gallic acid, or preventing its absorption by the hide. Glucose is also absorbed, but dextrine appears quite indifferent. Distilled water dissolves a small quantity of the hide, so that allowance must be made for that.

H. T.

THE COLORING MATTER OF THE RED AND YELLOW DAHLIA.—Roland Williams (*Journal of Society of Dyers and Colorists*, **3**, 2.) The author has prepared solutions of these two varieties, by boiling the flowers in water and using the decoctions for dye testing. Wool and silk were colored without mordants, but on first mordanting with alum, or tin salt, wool, cotton and silk were all beautifully colored.

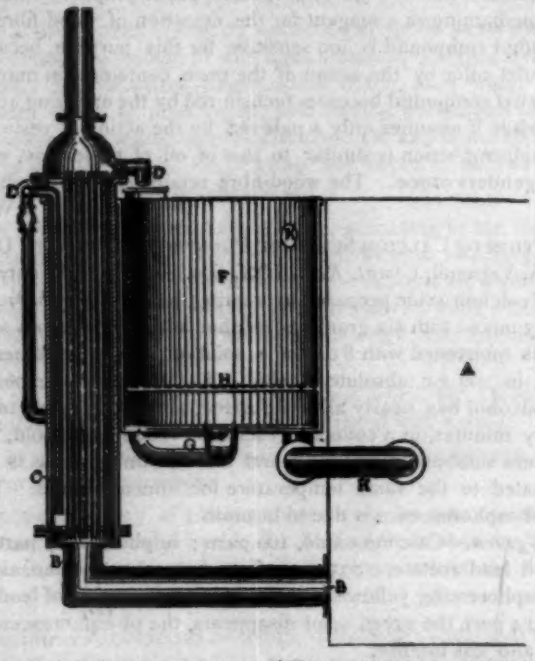
With alum, the color produced was a golden brown, the solution from the red dahlia giving the darker shade. With tin salt the red produced a cinnamon brown, and the yellow a good yellow shade. All of these shades, whether obtained from the red or yellow flowers, were "fairly fast both to light and soap."

The solutions were so sensitive to alkalies that they may be used as indicators in acidimetry, a fact which the author proved by actual experiment.

H. T.

A NEW METHOD AND APPARATUS FOR EXTRACTING DYEWOODS FOR IMMEDIATE USE IN DYEING, ETC. J. B. Wilkinson (*Journal Society of Dyers and Colorists*, **3**, 18.)—The apparatus consists of the dye cistern *A*, the extractor *F*, and the cylindrical vessel *C*. From the bottom of *A* a current of water comes into *B*, through which it passes to *C*. This vessel is for the purpose of causing a current and raising the water through the pipes in *C*, from *B* to *D*. This is accomplished by having the pipes in *C* surrounded by steam. *E* is a flange, which prevents the steam getting any higher, the pipes being open at the top. The current of water rises above these, and passes forward into the vessel *F*. This vessel contains the chipped wood—logwood, fustic, etc. The water passes down pipe *G*, outside the vessel, and is delivered from underneath, entering between the bottom of the vessel and the perforated grate *H*, which sustains the dye materials. The water which

is, perhaps, a trifle above the hot water point, passes up through the wood, and down another pipe, *K*, then into the dye vessel. The apparatus is best arranged with two extractors, the cylinder can raise the liquors for both, and one can be emptying and filling while the other is in use. The advantages



claimed may be briefly summed up as follows: (1) Saving of labor, fuel and time; (2) dispensing with the use of cages and bags; (3) freedom from small pieces of wood and bags; (4) more thorough extraction of the color from the dye woods. H. T.

A Delicate Reagent for the Detection of Active Oxygen.—C. Wurster (*Berl. Ber.* **19**, 3,195), finds that tetramethylparaphenylenediamine is an exceedingly sensitive test for active oxygen. In neutral or acetic acid solution, this substance assumes an intense violet-blue color by the action of oxidizing agents. By further oxidation, the blue color is changed to red, and finally the liquid is bleached, owing to the formation of a colorless compound that is not easily characterized. Test papers prepared with the compound are made and sold by Schuchardt, of Görlitz, and their great sensitiveness permits the detection of such small traces of active oxygen that Schoenbein's theory, according to which oxygen becomes active in all oxidations, seems to be confirmed. Its presence may be detected in the air, in the neighborhood of flame, in the juices of plants, and even on the human skin. Since all oxidizing agents color the paper violet and finally bleach it, it cannot serve for the detection of isolated active oxygen, but will at once indicate the possibility of

a disengagement of chemical energy from peroxidized molecules. Silver oxide, and the peroxides placed on the moistened paper at once color it violet, thus plumboso-plumbic oxide causes the reaction, while lead monoxide is without effect.

The same author (*loc. cit.* 3,217) proposes a paper prepared with dimethyl-paraphenylenediamine as a reagent for the detection of wood-fibre in paper. The tetramethyl compound is too sensitive for this purpose, because it will assume a violet color by the action of the resin, contained in many papers; but the dimethyl compound becomes fuchsin-red by the oxidizing action of the wood-fibre, while it assumes only a pale red by the action of resin. In both cases, the oxidizing action is similar to that of oil of turpentine, whose slow oxidation engenders ozone. The wood-fibre retains much insoluble resin.

W. H. G.

PREPARATION OF CALCIUM SULPHIDE PHOSPHORESCING WITH DIFFERENT COLORS. (A. Verneuil, *Compt. Ren.*, **103,** 600.)—*Violet.*—Twenty grammes of pulverized calcium oxide prepared by treating the shell of *hypopus vulgaris*, are intimately mixed with six grammes sulphur and two grammes starch, and the mixture is moistened with 8 c.c. of a solution of 0·5 grammes bismuth basic nitrate in 100 c.c. absolute alcohol. The mixture is exposed to the air until the alcohol has nearly all evaporated, and then heated to a cherry-red for twenty minutes, in a covered crucible. When quite cold, the upper layer of calcium sulphate is removed, and the remaining mass is powdered and again heated to the same temperature for fifteen minutes. The violet color of the phosphorescence is due to bismuth.

Yellowish-green.—Calcium oxide, 100 parts; sulphur, thirty parts; starch, ten parts, and lead acetate, 0·035 part, furnishes, when heated as before, a sulphide phosphorescing yellowish-green. If the proportion of lead acetate is increased to 0·4 part, the green color disappears, the phosphorescence is yellowish-white and less intense.

Orange-yellow.—The same mixture as before, using 3·5 lead acetate. Calcium sulphide made by reducing the pure sulphate in a current of hydrogen or carbon monoxide does not phosphoresce, and that made by reduction with starch phosphoresces but little. It would follow that pure calcium sulphide is not phosphorescent, and that the phosphorescence is due to small quantities of silica, phosphates, alkalies and magnesium, derived from the shells from which the lime is obtained.

W. H. G.

AN APPARATUS FOR THE RAPID PERFORMANCE OF NITROGEN ESTIMATIONS.—M. Raulin (*Bul. Soc. Chim.* **47,** 94) describes a method for rapid nitrogen estimations by Dumas' method. A copper tube, 1·8 metre long and 18 mm. in interior diameter, is surrounded in four places by brass refrigerating tubes, through which a stream of cold water flows. Three different substances for analysis are placed between these refrigerants, and the remaining space in the tube is filled with copper oxide and copper gauze as usual. A stream of carbon dioxide is passed through the tube, and the three combustions may be made in rapid succession. The volumes of gas evolved are compared with that of a volume whose weight has been previously calculated.

A deduction must be made from the observed volume of nitrogen for the nitrogen evolved from the acid in the carbon dioxide generator, and correction is arrived at by observing the volume of gas that collects in a given time before and after each combustion, and noting the time of combustion.

W. H. G.

PHOTOGRAPHIC NOTES.—Fuming sensitized albumen paper with common carbonate of ammonia, instead of with aqua ammonia is highly recommended by Prof. Rood. The sensitized paper salted down, as it were, in a cardboard box with sheets of filter paper, and freshly pulverized carbonate of ammonia, will keep for weeks without discoloration, and is not affected by the salt coming in contact with it. In printing, the paper is backed up with a pad charged with the freshly pulverized salt. C. F. H.

THE NEW WOODBURY photographic tissue, according to Mr. Beach, works very satisfactorily, being easy of manipulation, without requiring any extra operation or treatment with castor oil or kindred substances, whilst the results obtainable are said to equal the finest glass negatives, from which they are not distinguishable, except by the difference in weight and thickness.

C. F. H.

INSTEAD of yellow screens in orthochromatic work, Mr. Debenham coats the inside surface of his lens with collodion stained with aurine. C. F. H.

CRACKS in oil paintings are said to disappear when screens are used in copying on orthochromatic plates. C. F. H.

THE FREQUENT jarring of photographic lenses, by many forms of instantaneous shutters in use, is said by Mr. W. A. French to start the balsam with which the glasses are cemented, and ultimately to impair the efficiency of the lens. C. F. H.

THE POISONOUS PROPERTIES OF HOPS. (*Hopéine.*)—It is well known that the soporific effect produced by beer upon the nervous system is strong in proportion to the amount of hops in its composition. Some English beers made with wild hops from America, being condensed in vacuum, led to the discovery of a narcotic alkaloid contained in hops, and as the plant enters in such small quantities into the manufacture of beer, it was supposed that this alkaloid must have a very powerful action considering the quite sensible narcotic effect of the beverage. By boiling the wort with large quantities of American hops, evaporating in vacuum and treating the residue with alcohol, a solution of the alkaloid of hops was obtained, possessing properties in the highest degree poisonous. It was not possible, however, to extract pure *hopéine*, but later it was separated by exhausting the hops by an acid solution of sugar. It was evaporated in vacuum, treated with absolute alcohol, and the impurities removed by treating with ether, chloroform and benzole. *Hopéine*, as a narcotic, resembles morphine in its effects; it acts, however, more powerfully than the latter when used in hypodermic injections. To the taste, as well as in its reactions and derivations, it presents a marked difference. *Hopéine* is indicated by the following formula: $C^{18}\,H^{20}\,NO^4 + H^2O$. It is in the form of a white, crystalline powder, not easily soluble in water,

but quickly dissolved in forty parts absolute alcohol. Perfectly white when pure, it turns slightly yellow when exposed to the air. In decomposing, it emits the odor of hops, but otherwise is inodorous. The salts of *hopéine* are in great part crystalline and soluble in water. They contain from one to five molecules of H^2O, and possess the poisonous properties of the pure alkaloid. On the tongue, *hopéine* produces a burning sensation, which at first hides a decided bitter taste. A small dose of it brings sleep, a large dose produces coma and death by paralysis. The ingestion of even ·05 g. leads to symptoms of poison; ·1 g. is a dose dangerous to man; ·1 g. to ·05 g. will kill animals, such as dogs, cats, etc., in less than four hours. All the antiseptic properties of hops, which have not before been explained, are due to *hopéine*, and it may be hoped that it may find a useful application in the treatment of putrid diseases, if they succeed in killing the microbes in the blood itself by hypodermic injections. Up to this time all attempts in this direction failed, because the known antiseptics could not be injected in quantities sufficient to effect healing without imperilling health or life. *Hopéine* unites antiseptic with narcotic action, and it is the only known alkaloid possessing these two properties in so high a degree. To study the antiseptic powers of *hopéine*, many experiments were tried on fermenting liquids. In every case the microbes perished in less than an hour, and a stronger dose rendered their destruction immediate. The progress of decomposition was arrested, and when the action of germs carried by the air to the liquids under treatment had thus been hindered, fermentation could not be re-induced by a temperature favorable to their development. It can be concluded, after that, that the destruction of the ferments was radical. A mixture of fresh milk and cheese in decomposition curdles and decomposes in a few hours at a favorable temperature, while, by the addition of *hopéine* curdling is produced only after twenty hours, and the odor proving decomposition completely disappears. The same effects were produced on blood. In both cases the opacity of the liquids prevented microscopic examination. The pure alkaloid is so dear, its preparation being so expensive, that its industrial use cannot be expected; but it deserves the attention of the medical profession, as it may be useful in the treatment of certain diseases.—(*Dingler's Polytech. Jour.*)—*Bul. de la Soc. d'Encour, etc., July, 1886.* C.

Manner of Retarding Combustion.—The *Moniteur Industriel* describes a process, due to M. Ebert, of Dresden, by which the combustion of coal may be retarded, in order to reduce the consumption as far as possible, in certain metallurgic operations. The ore and the coal are pulverized or granulated. To the mixture or to the coal alone is added, before introduction into the furnace, a refractory substance such as soluble glass. This protects it against the action of the flame until the ore has acquired the proper degree of heat. Then the dissolution takes place and the carburetted metal in liquid state is separated from the dross in small drops. The success of the operation is a question of proportion.—*Chrom. Industr., Sept. 19, 1886.* C.

Clarifying of Oils by Permanganate of Potash.—The method is generally as follows: After having dissolved one kilogram of small crystals

of permanganate of potash in seven gallons of water (according to Mitscherlich, this product is soluble in fifteen to sixteen parts cold water), to this solution—which is of an intense purple color—thirty kilograms of the oil to be clarified is added little by little. The whole is allowed to stand two days, but is stirred very frequently. At the end of that time, four and one-half gallons of water is added and five kilograms of the hydrochloric acid of commerce, 20° to 22° B., and the whole stirred again. After a few days, the acidulated water is carefully drawn off, the oil is treated with hot water to cleanse it from traces of acid, and is then passed through a charcoal filter. Linseed, poppy, olive, palm and fish-oils can be successfully clarified in this manner. —*Chron. Industr., Sept. 12, 1886.* C.

SUGARS.—Type, $C_6 H_{12} O_6$. (*Schutzenberger's Traité de Chimie, Générale*, **5**. Paris, 1887.—*Phenose.*—Under this name is known an uncrystallizable and deliquescent sugar, which is very soluble in water and in alcohol, insoluble in ether. It was obtained by Carius in fixing upon benzine three molecules of hypochlorous acid,

$$C_6 H_6 + 3\,Cl\,H\,O = C_6 H_9 O_3 Cl_3,$$

and in treating the chlorinated product thus obtained, with sodium carbonate,

$$C_6 H_9 O_3 Cl_3 + 3\,H_2 O = 3\,H\,Cl + C_6 H_{12} O_6.$$

This synthetical sugar does not ferment, but it browns in the presence of alkalies and in the presence of acids and reduces Fehling's liquid. R. L. B.

MILK SUGAR.—*Lactose*, $C_{12} H_{22} O_{11}$, $H_2 O$. (*Schutzenberger's Traité de Chimie Générale*, **5**. Paris, 1887.)—From a chemical point of view, milk sugar stands midway between grape sugar and cane sugar. Like glucose, it browns in the presence of alkalies, and in alkaline solutions exerts a reducing action upon metallic compounds.

A saturated, aqueous solution of lactose, at 10° C., contains 14·55 for 100 of sugar. Freshly prepared solutions possess a greater dextrogyrous rotary power than do those which have been kept some time. Using a one per cent. solution of glucose, and Fehling's solution as usually prepared, one molecule of anhydrous glucose reduced 5·26 molecules of cupric oxide. Using a solution of milk sugar of the same strength (one part to 100) and Fehling's solution, one molecule of anhydrous lactose, $C_{12} H_{22} O_{11}$, reduces 7·4 molecules of cupric oxide.

Recent experiments by M. G. Bouchardat have proven that this carbohydrate, hitherto supposed to exist only in the milk of the mammalia, is present also in the milky juice of some plants belonging to the Natural Order *Sapotaceæ*.

Milk sugar does not ferment in the presence of brewer's yeast, but certain bacilliary ferments (schizomytes) transform it into alcohol. This reaction explains the possibility of obtaining from milk fermented liquors; such, for example, as the nutritious koumiss, which is prepared from mares' milk by the Tartars, as they roam over the vast steppes of Asia.

NOTE.—If Bouchardat's experiments shall be confirmed, the origin of the intoxicating liquor prepared in Africa from the flowers of certain species of

Bassia, will no longer remain unexplained chemically. A single tree of *Bassia longifolia*, it is stated, will yield from 200 to 400 pounds of flowers collected after they have fallen, and these flowers are largely consumed in the preparation of spiritous liquors. R. L. B.

TARTRAZIN. (W. H. Richardson *Journal Society of Dyers and Colorists*, **3**, 1).—Tartrazin, according to its method of preparation, possesses some resemblance to chrysamine. The commercial article is a sulphonic acid, thus differing from chrysamine. Tartrazin gives, with basic coal-tar colors, a series of well-defined precipitates, which may be regarded as the tartrazinates of the respective color bases.

Elementary tartrazin forms a yellow powder, sparingly soluble in water and alcohol, insoluble in dilute acids, easily soluble in warm concentrated acetic or hydrochloric acids. The acetic acid solution is rendered colorless by zinc powder, and becomes violet on standing in the air. The tartrazinates of the metals are mostly sparingly soluble in water. The barium salt is prepared by adding barium chloride to a solution of tartrazin in ammonia. Rosaniline tartrazinate is best prepared by mixing dilute solutions of commercial tartrazin and magenta, and allowing to stand. The brown flocculent precipitate may be purified from dilute alcohol or boiling water. Dried at 100°, it forms a greenish powder, which behaves as a very stable salt. Wool is dyed a color somewhat yellower than with the ordinary rosaniline salts. H. T.

SOME ALLEGED NEW ELEMENTS.—A. Pringle (*Chem. News*, **54**, 167), claims to have discovered six new substances in some lower silurian rocks in Selkirk. Five are said to be metals, and the other is a substance resembling selenium, and which he calls *hesperisium*. One metal is like iron, but does not give the rhodanate reaction, nor that with tannin. Another resembles lead, is quite fusible and volatile, and forms yellow and green salts; another is black, and he names it *erebodium*; the fourth is a light-gray powder, and the last is dark in color. For three of these elements, the author assigns the equivalents 95·4, 43·6 and 74. W. H. G.

THE EQUIVALENT OF GADOLINIUM OXIDE. By A. Nordenskiold (*Comptes Rendus*, **103**, 795).—Gadolinium oxide is a mixture of the oxides of yttrium, erbium and ytterbium, and was first obtained from the gadolinite found at Ytterby. It is precipitated by ammonium oxalate and also by potassium sulphate, and the three constituents cannot be separated quantitatively. Although this mixture has been separated from a number of different minerals and by different methods, the greatest variation for the mean value of its molecular weight, which is 261·9, is only one per cent., a variation that is within the error of experiment. The curious fact follows that although gadolinium oxide is not the oxide of a simple substance, but a mixture of three isomorphous oxides, it has a constant molecular weight, even when obtained from totally different minerals found in widely separated localities. [See on this point Prof. Crookes' remark, in his address, "Genesis of the Elements."—ED.] W. H. G.

THE ACTION OF ELECTRIC DISCHARGES ON PURE NITROGEN. By J. J. Thomson and R. Threlfall (*Proc. London Royal Soc.* **40**, 329.)—When strong electric discharges are passed through pure nitrogen under a pressure not

more than twenty millimetres, a diminution of volume takes place, and after a time attains a maximum which is greater as the pressure is lower. With a pressure of eight millimetres, the decrease amounts to eight or ten per cent. of the original volume. By long heating to 100°, the gas returns to its original volume. The authors believe that this phenomenon is caused by the formation of an allotropic form of nitrogen.

The same authors have found (*loc. cit.*, 340,) that the most powerful electrical discharges do not occasion the formation of ozone when passed through oxygen placed in a strong electrical field. W. H. G.

THE ATOMIC WEIGHT OF GOLD.—Gerhard Krüss (*Berl. Ber.* **20,** 205,) has determined the atomic weight of gold by the analysis of neutral trichloride and of potassium gold bromide; for a mean value he has found 196·669, the maximum of five methods being 196·741, while the minimum was 196·619. He regards 196·64 as the atomic weight most probably correct.

W. H. G.

GEOLOGY AND MINERALOGY.

CARD TO GEOLOGISTS.—The fourth meeting of the American Committee of the International Congress of Geologists, which has represented the United States in the International Sessions at Paris, Bologna, and Berlin, was held in Albany, on April 6th and 7th. The business it transacted was of unusual importance, and is earnestly commended to the attention of all geologists who may read this notice. At a previous meeting of the committee, sub-committees had been appointed and charged with the duty (each under a separate chairman) of co-operating in the production of a report which should embody the best thoughts of American Geologists on the several subjects into which the geological column was divided. This plan was found to be objectionable on account of the wide dispersion over the United States of the members of the sub-committees, which rendered co-operation difficult. Accordingly, the plan of the English Committee at the last session of the Congress was substituted, which consisted in appointing reporters for each of the subjects, and making them answerable for the preparation of a report. The duty of these reporters will be, not to confine their reports to the presentation of their own views, or those of any given small number of geologists; but to elicit, by personal correspondence, and in every other available manner, the views of all students of these subjects who can be induced to express any; and to resume these views in a paper to be submitted to the Committee and ultimately to the Geological and Geographical Section of the American Association for the Advancement of Science. In this way a fair representation can be made, at the next Congress, of American geological thought. The following is a list of the subjects to be treated and the persons selected to present them, and *all geologists are requested to aid the important national work to be undertaken, by sending to the appropriate reporter, hereby indicated, any suggestions which may occur to him as bearing on his work. Those who neglect this appeal, cannot accuse the American Committee of slighting the views of their countrymen.*

"Quaternary, Recent and Archæology."—Major J. W. Powell, Director United States Geological Survey, Washington, D. C.

"Cainozoic" (Marine).—Prof. E. A. Smith, University of Alabama, Tuscaloosa County, Ala.

"Cainozoic" (Interior).—Prof. E. D. Cope, 2102 Pine Street, Philadelphia.

"Mesozoic."—Prof. Geo. H. Cook, Rutgers College, New Brunswick, N. J.

"Upper Palæozoic."—Prof. J. J. Stevenson, University of the City of New York, (Carbonic); and Prof. H. S. Williams, Cornell University, Ithaca, N. Y., (Devonic).

"Lower Palæozoic."—Prof. N. H. Winchell, University of Minnesota, Minneapolis.

"Archæan."—Dr. Persifor Frazer, 201 South Fifth Street, Philadelphia.

It is the intention of the Committee to hold a meeting next summer at which these reports shall be considered, discussed and amended; and to bring the conclusions arrived at by them before the American Association for the Advancement of Science (or rather Section "E" thereof) at its meeting to be held in New York City on August 10th, thereafter.

The resolution herewith subjoined was adopted by the American Committee:

"That we recommend to American geologists the acceptance of the conclusions of the International Congress of Geologists; but that we will be prepared to advocate certain changes in the details in case these questions are ever re-opened in the International Congress; said changes to be formulated at a subsequent meeting of the Committee, it being understood that the Committee will present such additions as are deemed necessary by American geologists to the Congress of London, of 1888."

PERSIFOR FRAZER (*Secretary American Committee*).

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, April 20, 1887.*]

HALL OF THE INSTITUTE, April 20, 1887.

MR. JOSEPH M. WILSON, President, in the Chair.

Present, 136 members and sixteen visitors.

Additions to membership since last meeting, six.

The Special Committees on State Weather Service and on PAUL LA COUR'S protest, reported progress and were continued.

A letter was read from Mr. JOHN J. HOLTZAPFEL, of London, accepting election as a corresponding member.

Sergeant T. F. TOWNSEND, of the United States Signal Service, read a paper "On the Use of Oil for Stilling Waves," with a description of a new Oil Distributor for the Use of Mariners. Referred for publication.

MR. ALEX. E. OUTERBRIDGE, JR., of Philadelphia, described a new Method of obtaining Castings from Carbonized Fabrics, and exhibited numerous specimens of castings in iron obtained in this manner.

Final action was taken on certain Amendments to the By-Laws. Adjourned.

WM. H. WAHL, *Secretary*.

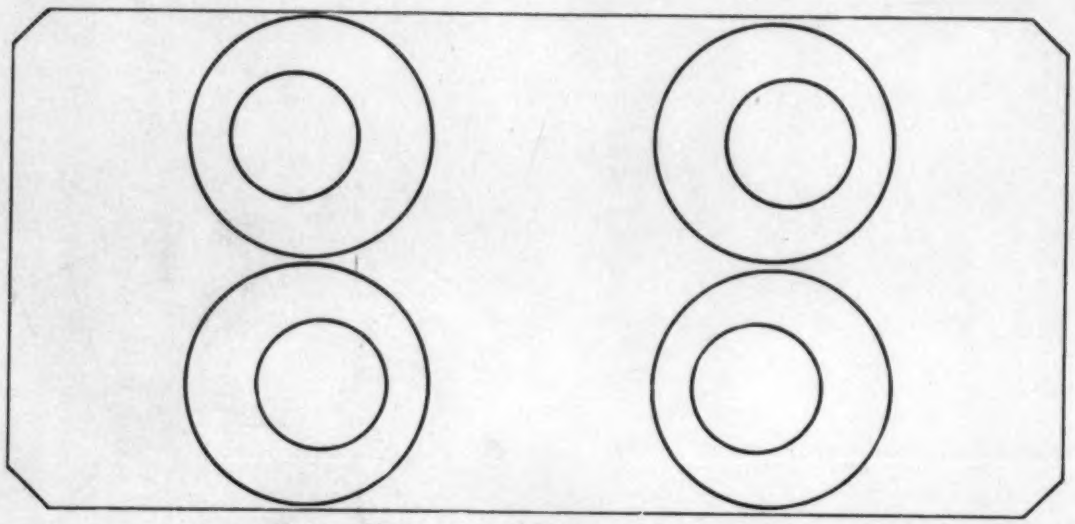


FIG. 9.—Phenomenon of Horizontal Moon.—Reute.

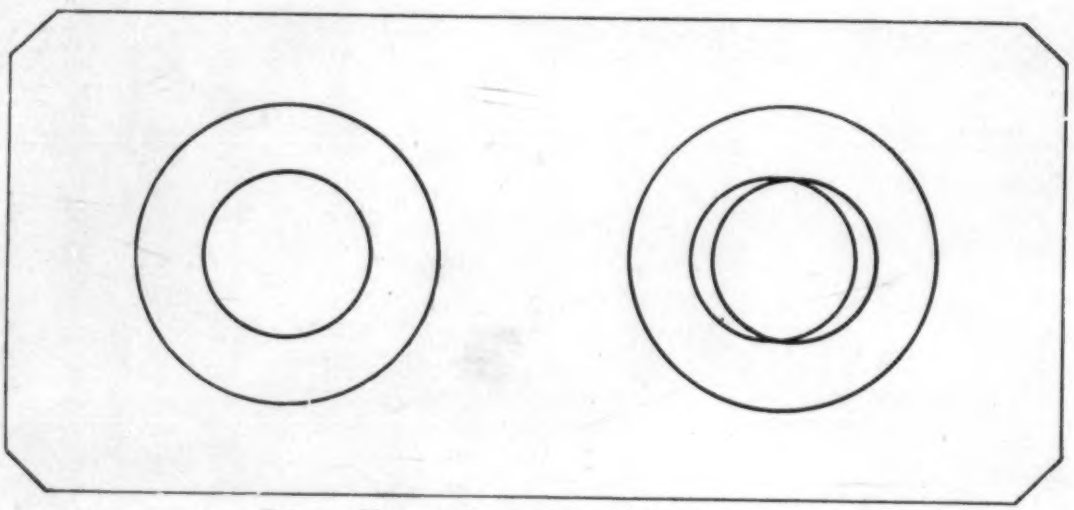


FIG. 10.—Phenomenon of Horizontal Moon.—Himes.

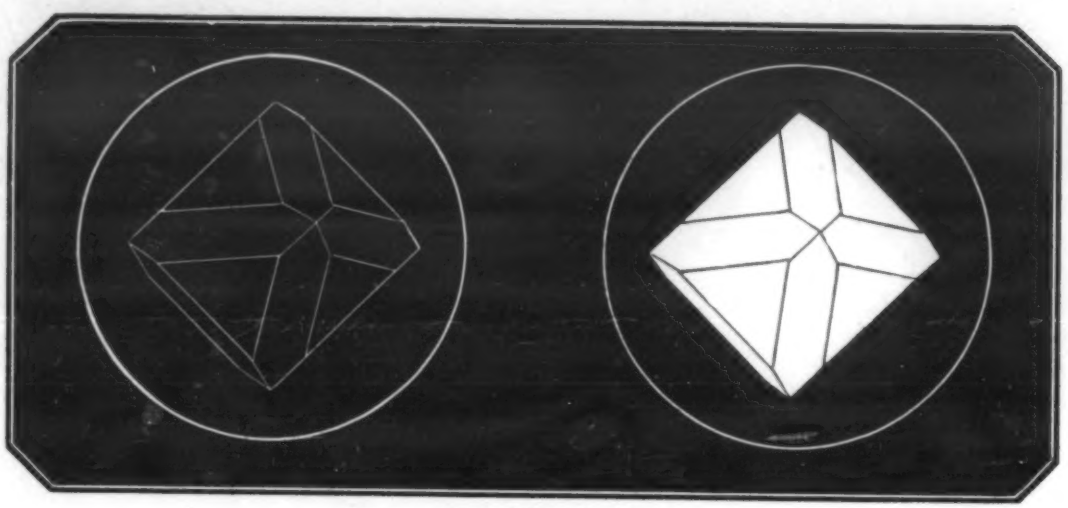
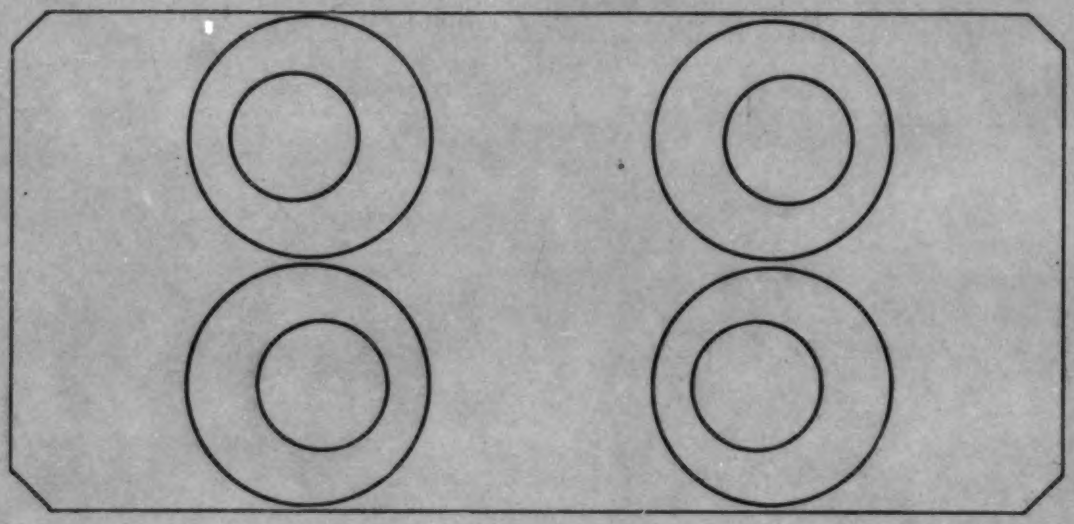
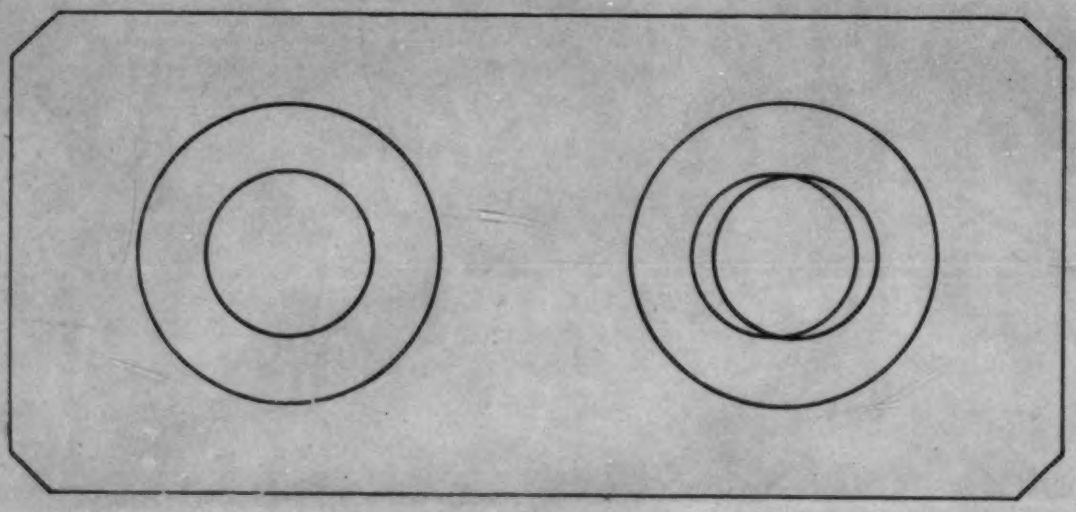
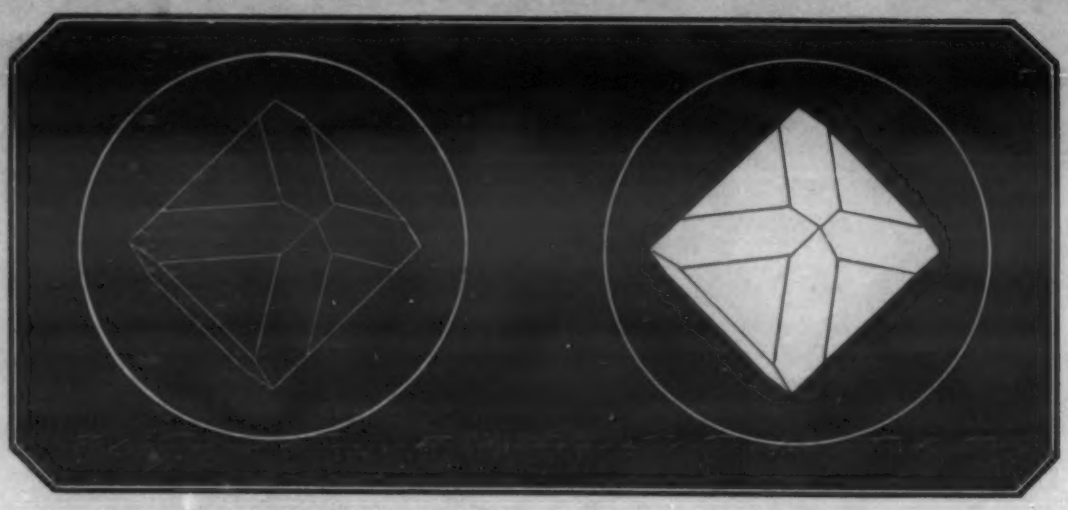


FIG. 13.—Crystal Model with Lustre.







These plates are printed for the convenience of those who may wish to mount them as stereographs.